CHAPTER T8 ELECTRICAL WORKS

T8.1 Scope of Work

These Specifications cover all the works necessary for designing, detailing, manufacturing, supplying, testing, finishing, painting, packing for export, insuring, shipping, delivering to the Site, erecting, site testing and cooperating in the commissioning of all the electrical works as classified as follows:

(1) Lighting and receptacle systems in the Dam Control House
(2) Lighting and receptacle systems in the Gate Control House
(3) Lighting and receptacle systems in the Valve Chamber including Access Shaft
(4) Lighting and receptacle systems in the Inspection Gallery and Grout Tunnel
(5) Lighting system for access road and dam crest
(6) Power receiving and power distribution systems
(7) Emergency power supply system
(8) Grounding system
(9) Dam leakage water drainage system

T8.2 General

Materials/equipment shall be new, the best of their respective kinds and such as are usual and suitable for work of like character. All materials/equipment shall comply with the latest issues of the specified standard unless otherwise specified or permitted by the PMO/Engineer.

Workmanship shall be of the highest class throughout to ensure reliable and vibration free operation under all possible operating conditions. The design, dimensions and materials of all parts shall be such that the stresses to which they may be subjected shall not cause distortion, undue wear, or damage under the most severe conditions encountered in service.

T8.2.1 Standards

The design, materials, manufacture, testing, inspection and performance shall, unless otherwise specified in these Specifications, conform to the authorized standards of the International Electrotechnical Commission (IEC) or equivalent national standards.

T8.2.2 Working drawings and catalogues

Working drawings, shop drawings of full size drawings shall be prepared and submitted by the Contractor to the PMO/Engineer for approval as specified herein without extra cost.

T8.2.3 Electrical and mechanical design

Switchgear shall be designed to mechanically endure short-circuit current without thermal and mechanical failure for one (1) second. All enclosures shall be of dust-proof and vermin-proof.

The enclosures shall be totally enclosed, by sheet steel panels not less than 2.3 mm thick, with angle or channel edge bent, seamwelded at corners, and ground smooth. Outside panels shall not be drilled or welded for attaching wires, resistors, or instruments.

Each enclosure shall be constructed so as to meet the required installation method; self-supporting, wall-recessed or wall-mounted type.

The degree of protection for the enclosures shall be as follows, conforming to IEC 144.

(a)	For indoor installation	IP41
(b)	For outdoor installation	IP54

The enclosure shall be provided with access doors to facilitate inspections of the equipment. The door shall be provided with suitable handles with locks.

Space heaters for 230 V or 400 V A.C. shall be provided inside the enclosure to prevent moisture condensation. A manual switch to control the heaters shall be provided in the enclosure.

T8.2.4 Measuring instruments

All measuring instruments shall be of flush-mounted, back-connected, dust-proof and heavy duty switchboard type. Each measuring instrument shall have a removable cover, either transparent or with a transparent window. Each instrument shall be suitable for operation with the current transformers and voltage transformers under both normal and short-circuit conditions.

Scale plates shall be of a permanent white circular or rectangular finish with black pointer and markings. The scale range shall be determined from the current transformer and voltage transformer ratios.

All measuring instruments shall be approximately 110 mm square enclosures and shall be provided with clearly readable long scale, approximately 240 degrees. The maximum error shall be not more than one and a half (1.5) per cent of full scale range.

The wattmeter and watthour meter for the low voltage circuit shall be of 3-element, 3-phase, 4-wire type with a reverse running stop.

T8.2.5 Indicating lamp assemblies

Indicating lamp assemblies for the enclosures shall be of the switchboard type, insulated for service voltage, with appropriately coloured lamp lenses and integrally mounted resistors for service voltage. The lamp lenses shall be of a material which will not be softened by the heat from the lamps.

Red indicating lamps shall be used for "ON" position and green lamps for "OFF" position.

T8.2.6 Nameplates and escutcheon plates

Each cubicle, panel, meter, switch and device shall be provided with a nameplate or escutcheon plate for identification. Each switchgear equipment shall be provided with a rating plate containing the necessary information specified in the relevant IEC standards.

The plates shall be made of weather-proof and corrosion-proof materials and shall not be deformed under the service conditions at the Site.

The entries on the plates shall be indelibly marked by engraving with black letter on a white background.

The language of all plates shall be English or in accordance with the instruction of the Employer.

T8.2.7 Painting

All outside panel surfaces shall be primed, filled where necessary, and given not less than two coats of synthetic undercoat. The finishing coat for the outdoor installations shall be a gloss paint and for the indoor installations shall be a semigloss paint.

The inside surface of the enclosures shall have two prime coats and one finishing coat of light cream colour.

The colour scheme for the finishing coats of all equipment, frames for meters and relays, and switch handle shall be proposed by the Contractor with presentation of colour samples or colour chips and shall be subject to the PMO/Engineer's approval.

The humid and tropical conditions shall be taken into account on selection of the paints and painting procedure.

T8.3 Wiring

T8.3.1 General

All wiring shall be done with PVC insulated wire not less than 2.5 sq.mm except for electronics devices. A suitable wiring duct system shall be installed for all interpanel and front-to-rear panel wiring which will provide easy access for inspection and replacement. As far as possible all wiring shall be installed in wiring ducts.

All wiring from hinge door panels to the fixed panels shall be done with flexible conductor of equivalent size.

Wiring between terminals of the various devices shall be point to point. Splices or tee connection will not be acceptable. Wire runs shall be neatly trunked or clamped.

Exposed wiring shall be kept to minimum, but where used shall be formed into compact groups suitably bound together and properly supported.

Instrument transformer secondary circuits shall be grounded only at the first panel entered, and shall not be grounded at any point of outside of the enclosures.

Cable supports and clamp type terminal lugs shall be provided for all incoming power wiring terminated at each panel. All wires shall be marked near each terminal end with circuit or wire designation. These markers shall be of an approved type and permanently attached to the conductor insulation.

T8.3.2 Phase arrangement

The standard phase arrangement when facing the front of the panel shall be R-S-T-N, and R-N-S from left to right, from top to bottom, and front to back for A.C. three-phase and single-phase circuits and N-P from left to right, P-N from top to bottom and front to back for D.C. polarity. All

relays, instruments, other devices, buses and equipment involving three-phase circuit shall be arranged and connected in accordance with the standard phase arrangement where possible.

T8.3.3 Wiring color code

All wires shall be colored as follows:

Circuit	Color
Voltage transformers	Red
Current transformers	Black
A.C. circuit	Yellow
D.C. circuit	Blue
Grounding circuit	Green with yellow stripes

T8.3.4 Phase and polarity color code

Following colored ferrules shall be provided on each wire in order to identify phase and polarity.

Phase and Polarity		Color
A.C., three-phase,	first phase	Red
	second phase	Yellow
	third phase	Black
A.C., single-phase,	first line	Red
	second line	Yellow
Neutral		Black
Grounding		Green with yellow stripes
D.C.,	positive	Red
	negative	Blue

T8.4 Terminal Blocks

Terminal blocks for control wiring shall be rated at not less than 600-volt with cover and be of the molded type with barriers.

White or other light-coloured marking strips, fastened by screws to the molded sections at each block, shall be provided for circuit designation.

Each connected terminal of each block shall have the circuit designation placed on the marking strip with permanent marking fluid. The terminal arrangement, including the terminal blocks for PT and CT circuit connections, shall be subject to the PMO/Engineer's approval. Spare marking strips shall be furnished with each block.

At least 10 per cent spare terminals shall be provided for each terminal block group.

T8.5 Tests

The tests to be carried out before shipment at the manufacturer's plant and at the Site shall be as stated in the relevant Clause.

T8.6 Lighting and Receptacle Systems

T8.6.1 Scope of work

The following lighting and receptacle systems shall be supplied and installed in the dam control house, gate control house, valve chamber including access shaft inspection gallery and grout tunnels as shown on the Drawings.

(a) Indoor lighting and receptacle systems

(b) Single or three phase motor power system for some of the building service equipment installed in the buildings.

(c) Telephone piping and cabling system for some of the building services in the building and grout tunnel and inspection gallery.

The following apparatuses and materials shall be furnished and installed to complete the lighting and receptacle systems.

(i) Panelboards
(ii) All conduits and electrical cables and wire for the panelboards, lighting fixtures, receptacle, etc.
(iii) Lighting fixtures including bulbs and support
(iv) Conduit piping and wiring works
(v) Miscellaneous materials to complete the systems.

T8.6.2 Electrical apparatuses and materials

(a) Panelboards

(i) Construction requirement

The panelboards panels shall be of wall-recessed type for indoor installations and of wall-mounted type for outdoor installations and shall generally be constructed in as specified hereinbefore.

A copper ground busbar with ample size shall be provided in the panel. Clamp type grounding terminals shall be provided for grounding system.

Electric circuits, classification, rating and numbers of molded case circuit breakers, electromagnetic contractors, switches, etc. for the panels shall conform to the Drawings. A card holder with a card for each circuit designation shall be provided with the back of each panel's door plate.

(ii) Molded case circuits breakers

The molded case circuit breakers for the panels shall be one- or three-pole for A.C. circuits and two-pole for D.C. circuits, manual operated, fixed type with time-delay overcurrent tripping and magnetic instantaneous short-circuit current tripping mechanism, and with residual current tripping mechanism as required.

The molded case circuit breakers shall be rated as follows:

<u>For A.C. circuits</u>

i)	Rated insulation voltage	600 V
ii)	Rated operational voltage	
	- for three-pole	400 V
	- for one-pole	230 V
iii)	Rated short-circuit breaking current	2.5 kA
iv)	Rated residual current (if required)	30 mA

<u>For D.C. circuits</u>

i)	Rated insulation voltage	250 V D.C.
ii)	Rated operational voltage	110 V D.C.
iii)	Rated short-circuit breaking current	2.5 kA

The rated frame currents and the rated trip currents shall be determined by the Contractor to suit the rated short-circuit breaking current and the overcurrent protection and shall be subject to the PMO/Engineer's approval.

(iii) Accessories

The following items shall be provided for the panelboards:

i) Nameplate for each panel
ii) Foundation bolts and nuts
iii) Grounding pads
iv) Other necessary accessories

(b) Lighting fixtures

The lighting fixtures shall be complete with ballasts and lamps. Fluorescent lighting fixtures shall be equipped with complete fittings for A.C. 230 V, 50 Hz source and a ballast or ballasts of high power factor.

Mercury lighting fixtures shall be equipped with a screwed base lamp holder suitable for high-pressure mercury lamp, and appropriate ballast of high-power factor for stable operation.

The lighting fixtures for outdoor lighting shall be of rain-proof type. The lighting fixtures to be installed in wet and damp places shall be of moisture proof.

(c) Insulated wires and power cables

The sizes of insulated wires and power cables shall conform to the Drawings.

Insulated wires to be used for indoor wiring shall be of 600 V grade, PVC insulated single-core tinned copper wire.

Power cables to be used for connection between the terminal point and the panelboards shall be of 0.6/1.0 kV crosslinked polyethylene (XLPE) insulated, PVC sheathed cable.

(d) Joint boxes

The boxes for wire joints to be concealed in concrete shall be of galvanized sheet steel type and shall be fitted with appropriate covers, where necessary, to set the boxes flush with the finished surfaces of the structure. The boxes to be used for the exposed

installation shall be of galvanized cast steel or alloy to be fitted with appropriate fittings and covers.

(e) Tumbler switches

Wall switches shall be of fully enclosed, recessed or surface mounting, tumbler type, rated at 300 V, 15 amperes.

(f) Receptacles

Receptacles shall be of 3-pin type rated at 250 V, 15 A available in Mauritius, and shall be of wall-recessed or surface-mounted type with appropriate cover.

Receptacles to be installed in wet and damp places shall be of moisture-proof type.

Unless otherwise noted on the Drawings, the mounting height of the outlet shall be 300 mm above floor to the center of the box.

(g) Conduits

The rigid steel conduits of thick wall galvanized type shall be used for cabling and wiring. The conduits shall have a minimum thickness of 2.3 mm and have a minimum inside diameter of 16 mm. Where the conduits are installed in expose, they shall be coated with epoxy enamel of which color shall be directed by the PMO/Engineer.

(h) Miscellaneous materials

All apparatus, accessories and materials, which have not been specifically mentioned but which are necessary for the efficient performance of the works, shall be provided by the Contractor.

(i) Motor control panels

The motor control panels shall be provided for power distribution and automatic control of the air conditioning and ventilation equipment etc. as required.

Each motor control panel shall be composed of the enclosure, busbars and withdrawable type motor starter units with molded case circuits breakers, electromagnetic contactors, relays, timers, terminal blocks, wirings and other devices necessary for the required controls. The control circuits voltage shall preferably be 230 V A.C. of single-phase. The required step-down transformers with adequate rating shall be contained in the motor control panel.

Indicating lamps for operating status and for fault annunciation shall be mounted on the front panel of the enclosure.

(i) Construction requirement

The motor-starter units shall be housed in the indoor installation, floor-starting or wall-mounted type metal enclosure and shall be withdrawable from the front panel.

(ii) Molded case circuit breaker

The molded case circuit breakers for the motor control panel shall be of three-or two-pole, manual operated type with rotary operating handle located on the starter unit panel front. It shall be possible to lock the circuits breaker in ON and OFF positions by means of padlock.

The molded case circuits breaker shall be provided with thermal time-delay overcurrent tripping and magnetic instantaneous short-circuit current tripping mechanism.

(j) Telephone cable

Telephone cable shall be installed in the conduit and pulled out by lead wire for connection of telephone set. Lead wire shall have the minimum length of 3 m and shall be provided with telephone outlet made by brass. Telephone cable for indoor use shall be of PVC TIVF 0.65 mm diameter. 2 cores in parallel or better equivalent.

T8.6.3 Installation

(a) General

All installation works shall be carried out by the Contractor in accordance with the applicable standard, these Specifications and the instruction of the PMO/Engineer. The arrangement of fixtures and apparatus shall conform to the Drawings. The Contractor shall submit working drawings for approval indicating routes and sizes of electrical wires and conduits.

(b) Lighting fixtures

The exact location and height of the lighting fixtures shall be determined by the Contractor from the structural and mechanical limitations of the building. The lighting

fixtures shall be installed in such a manner as to avoid obstructions and to give the proper illumination results, and shall not injure outlet boxes, conduits, walls, ceiling, etc. by their weights. Lamps shall be in the position at the completion of construction work.

(c) Conduit work

Conduit shall be concealed within or pierced through the structure without effect on their construction and strength. The cut ends of conduit shall be smoothed. Pullboxes shall be provided for the conduit system to give an easy leading in or replacement of the wires. The bending radius of conduit shall be not less than 6 times its inside diameter in case normal bend is not used.

Conduits to be buried in the ground shall have a factory-applied plastic resin, epoxy, or coal-tar coating system. The coverage over underground conduit shall not be less than 600 mm below the ground surface.

Exposed runs of conduit shall have saddles or sheet steel supports spaced not more than 1.5 meters and also shall be supported at least 2 positions. They shall be installed to run in parallel with or perpendicular to walls, structural members, or intersections of vertical planes and ceilings, with right-angle turns.

Outlet boxes or switch boxes with appropriate covers shall be provided at the places where the lighting fixtures, receptacles and tumbler switches are installed.

Conduit shall be installed in such a manner as not to allow condensation trapped in the conduit. U-shaped piping shall be avoided as far as possible. Conduits shall be connected with each other by means of screwed or non-screwed coupling and also shall be securely fastened to all sheet-metal outlet, junction and pull boxes with galvanized lock-nuts and bushings. Conduits in exposed work shall be screwed with boxes and other fittings. Connected portion of conduit system shall be coated with anti-corrosive paint. Exposed runs of conduit including boxes, supports and all other fittings shall be painted, of which color will be instructed by the PMO/Engineer.

The Contractor shall carry out the necessary precautions to prevent the lodgement of dirt, plaster, trash or damp in conduits, fittings, and boxes during the course of installation. A run of conduit which has become clogged shall be entirely freed of these accumulations or shall be replaced.

(d) Indoor cable laying

Cables shall be securely fastened along the structure with saddles or other suitable supports space not more than 1.5 meters apart, but not more than 1 meter apart where it is likely to come in contact with persons. Metallic racks and the like shall be installed in cable ducts and shafts for laying, where necessary. Conduits shall be utilized where the cables may be injured. Cables shall be laid in conduit where they are concealed in the concrete structure to protect the cables and to give an easy replacement thereof. In this case, the bore of conduits shall be not less than 1.5 times of outside diameter of cables. The bending radius of cable shall be not less than 6 times their outside diameter. The cables, when drawn into conduit, shall not be bent at more than 2 portions and there bending angles shall not exceed 180 degrees in total. Cable splicing shall be completely made by means of sleeve jointing, lapped with insulating tape, without increase of electrical resistance, deterioration of insulation strength and decrease of tensile strength. No splices shall be made except within panelboards, outlet boxes and junction boxes.

Wires shall be continuous from outlet to outlet and no splices shall be made except within outlet, junction boxes or panelboards. No oil or grease shall be used for wiring as a lubricant. The interior of conduit system shall be fully cleaned up before wiring.

(e) Cable laying in trench

The cables to be installed in the floor trenches where shown on the Drawings shall be laid on the bottom of the trench or fastened to the wall of trench in neat workmanship. Each cable shall be provided with tag to indicate circuit number or circuit designation. The cables to be fastened to the trench wall shall be supported with factory made devices at cables to be fastened to the trench wall which shall be supported with factory made devices at 1,500 mm intervals.

(f) Grounding

Unless otherwise directed by the PMO/Engineer, all non-current carrying metal parts of electrical equipment and fixtures shall be grounded through rigid steel conduit system. All joints of conduits shall be tight. The conduits shall be connected with the grounding system as far as applicable. Green colored PVC insulated wires shall be used for grounding purpose.

(g) Pull boxes

Pull boxes shall be installed approximately where shown on the Drawings. The exact locations of pull boxes shall be determined by the Contractor and shall be subject to the PMO/Engineer's approval. The pull boxes shall be of metal sheet galvanized type, the size of which shall be 150 mm x 150 mm x 100 mm.

(h) Other apparatuses

Switches, receptacles and other apparatuses shall be installed according to the Drawings. All apparatuses shall be securely screwed and fastened.

T8.6.4 Tests

(a) At the manufacturer's works

The tests required by the applicable standards shall be carried out by the Contractor before shipment at the manufacturer's shop and the test reports shall be submitted to the PMO/Engineer for his approval.

(b) At the Site

The following tests shall be carried out by the Contractor at the Site after the completion of installation.

a) Operation test
b) Measurement of insulation resistance (2 M-ohm or more)
c) Circuit continuity test

T8.7 Power Receiving and Power Distribution Systems

T8.7.1 General

The power receiving and power distribution system to be provided for supply of electric source for the Project shall include the following equipment and materials as shown on the Drawings.

(a) 20 kV power receiving equipment and materials such as poles, arms, conductors, insulators, cutout switch with fuse, 20 kV outdoor cubicles and other necessary accessories. Two receiving stations shall be constructed for low voltage power supply: One is of outdoor pole assembly type 50 kVA and the other is of outdoor cubicle type 75 kVA.

(b) Low voltage line materials such as poles, arms, conductors, cable,s cable terminals and other necessary accessories.

(c) Step-down transformers and 20 kV and low voltage equipment and accessories.

Step-down transformers of 20 kV/low voltage shall be installed under this Contract as shown on the Drawings.

T8.7.2 Conductor and cables

(a) Conductor and underground cable

20 kV line conductor shall be of 58 sq.mm Aluminium Cable Steel Reinforced conductor (ACSR). Low voltage line conductor shall be of 38 sq.mm Hard Drawn Copper Conductor (HDCC). The Japanese Industrial Standard (JIS) or equivalent shall be applied to the conductor.

600 V 22 sq.mm. three cores cross linked polyethylene insulated PVC sheathed cable with suitable cable terminals shall be supplied.

(b) Transformer drop wires

Transformer drop wires for pole mounted step-down transformers shall be of single-core PDC (6 kV cross-linked polyethylene insulated drop wire) 8 mm^2 to connect the primary line to the transformer primary bushings.

(c) Transformer secondary cables

Transformer secondary cables shall be of 600 V 3-1/2 and 4-cores or single-cored copper conductor, cross-linked polysthylene insulated, PVC sheathed cable. The sizes of cables shall be as follows:

Transformer capacity	Transformer 2ry
50 kVA	1 cct - 3-1/2C x 22 mm^2
30 kVA	1 cct - 3-1/2C x 14 mm^2

(Remark)
3-1/2C means 3 cores of full size and 1 core of a half size.

(d) Low voltage service wires

Low voltage service wires shall be of double cored copper conductor PVC insulated wire, size of the wires shall be of 8 sq.mm and 14 sq.mm.

(e) Joints and connectors

Midspan joints for power conductors shall be of compression type and shall be free from slipping off, damage to or failure of the conductors or any parts thereof at a load less than 2.5 times the working tension of the power conductors.

The electrical conductivity and current carrying capacity of the joints for the power conductors shall not be less than those of equivalent length of the conductors.

Connectors shall be of bolted or compression type.

T8.7.3 Insulators and fittings

(a) Insulators

Insulators of the following types shall be supplied:

- 20 kV line post type
- 20 kV tension set
- Low voltage spool type

20 kV line post type and disc type (tension set), and low voltage spool type insulators shall be as per those shown on the Drawings.

(i) Material and type

Insulators shall be made of porcelain glazed brown or other approved colour. The disc insulators for tension set shall be of ball socket type.

Spool type insulators shall be suitable for low voltage line use.

(ii) Number of disc insulators for tension set

Two (2) insulators of standard 254 mm x 146 mm disc type per string shall be applied for 20 kV overhead lines at every heavy angle and dead-end poles, in general.

(iii) Electrical mechanical characteristics

Electrical and mechanical characteristics of the insulators shall not be less than the values given below:

		Line post	Disc-type	Spool-type
Leakage distance	:	–	280 mm	50 mm
Power frequency flashover voltage, dry	:	105 kV	75 kV	15 kV
Power frequency flashover voltage, wet	:	75 kV	40 kV	8 kV
Impulse flashover voltage, positive	:	165 kV	105 kV	–
Ultimate mechanical strength	:	700 kg	7,000 kg	910 kg
		(Canti-lever)		(Transverse)

(b) Fittings for insulators

The conductors for 20 kV lines will be fixed to tension sets and/or line post type insulators.

Line post type insulator shall be fixed by galvanized steel bolt of not less than 22 mm in diameter and provided with spring washers and nuts for steel cross arms.

They shall be free from slipping off, damage to or failure of the complete conductors at a load less than 2.5 times the maximum working tension of the conductors.

A spool insulator with fitting bolt and nuts, and a strap with a set of mounting fixture as shown on the Drawings shall be supplied for each low tension spool type.

Preformed anchor grip shall also be used for dead end point of low tension lines. The conductors for low tension lines shall be fixed to spool insulators with bind wires. The preformed anchor grips shall be made of red brass.

The preformed grips shall be made of red brass and designed as side for gripping the conductors by wrapping at line post type insulator points.

The bind wires shall be annealed copper bare wires of 2.0 mm in diameter, and shall be used for low tension lines.

T8.7.4 Supports

(a) Type of supports

(i) General

Assembly of each support is shown on the Drawings.

Alternative supports may be adopted if proposed by the Contractor in his Tender and approved by the PMO/Engineer.

The poles shall be so designed as to apply same poles to all type of poles mentioned above considering interchangeability of the poles.

The above poles shall also be applied for low voltage lines, when required, with spool insulators.

(ii) Construction

Poles shall be galvanized steel tubes and each pole shall consist of two or three sections, to be jointed mechanically or by welding. Cross arms shall be made of galvanized steel channel and equivalent and each crossarm shall be fixed to the poles by means of through bolts, arm times, M type fixture of arms for angle and dead end types poles and other necessary accessaries.

Poles shall be provided with adequate holes for fixing low voltage spool insulator racks, a communication cable, crossarms and platforms for transformers as shown on the Drawing. Base plates of the poles shall be provided with a water drain hole.

(iii) Materials

(a) Steel tubular poles

Steel tubular poles shall be made of "carbon steel tubes" with the following mechanical properties, except where otherwise approved:

Minimum tensile strength:	41 kg/mm^2
Minimum yield strength:	24 kg/mm^2

(b) Structural steels

The Contractor shall propose suitable materials for the cross arms and other structural steel members of the supports.

(b) Design conditions

(i) Basic clearance

Ground clearance of the conductors and communication cable shall not be less than the following:

	22 kV	400/230 V	Communication cable
Road crossing	6.0 m	4.8 m	4.8 m
Along road	5.8 m	4.8 m	4.5 m
Other areas	5.2 m	4.8 m	4.5 m

- Design span and maximum working tension

Line	Design span	Max. working tension
22 kV line	60 m	290 kg
L.T. line	30 m	–
Communication cable	60 m	300 kg

- Wind pressures and temperatures

Maximum wind pressures on the conductors, poles, etc. shall be taken as follows:

- Conductors and cable : 25 kg^2 on the projected area
- Supports : 25 kg/m^2 on the projected area
- Insulators : 50 kg/m^2 on the projected area
- Transformer and other equipment : 50 kg/m^2 on the projected area

(ii) Factor of safety

Poles shall be so designed that no failure or permanent distorts shall occur when tested with applied loads equivalent to 2.0 times the maximum simultaneous loads.

(c) Pole foundations

Tabular poles shall be so designed as to have depth of 1/6 of total pole length below the ground at the minimum.

Steel base plates shall be designed against the assumed allowable compressive strength of soil, or 20,000 kg/m^2.

(d) Accessories

(i) Step bolts

Two numbers of step bolts for 22 kV lines poles shall be supplied. Step bolts shall be of 16 mm in diameter and 16 cm in effective length and fixed with double nuts to the frame.

(ii) Cross arms and platforms

Cross arms and platforms with necessary fittings shall be provided as shown on the Drawings.

(iii) Guy wire assemblies

- General

Guy wire assemblies shall be fixed to the upper portion of the poles and anchored to the ground.

The angle of guy wires against the poles shall be within 30 - 45 degrees.

Each guy wire assembly shall include a steel wire strand, a pole band, a guy insulator, preformed grips, a turnbuckle, an anchor rod with thimbles and an anchor plate.

The steel wire strand shall be connected to other components by means of preformed grips. Wire clips shall not be used for connection.

The guy wire assemblies shall be so provided that the same assembly shall be used in common with all types of tubular pole sets for 22 kV and low voltage lines.

- Mechanical characteristics

The guy wire assemblies shall be designed so as to support the following loads with the minimum factor of safety of 2.5.

Angle poles	:	Transverse component of the maximum tensions of conductors and communication cable caused by the specified horizontal angle of the line
Terminal poles	:	The maximum tensions of conductors and communication cable.

- Anchor foundations

Depth and size of anchor plates shall be derived from the following soil conditions so as to bear the guy wire tension with the minimum factor of safety of 2.5.

Weight of soil	:	1,500 kg/m^3
Angle of repose*	:	20 degrees

*: Angle between the guy line and slope of inverted frustum of a pyramid assumed to resist loads on the guy.

- Guy wires

Guy wires shall be the galvanized steel stranded wires of the following constructions.

Minimum diameter of individual wire	:	2.9 mm
Minimum number of wires in strand	:	7

Guy wires shall be supplied on drums.

(iv) Top fitting

Top fitting shall be designed as per previous clauses and supplied.

T8.7.5 Step-down transformers and other equipment

(a) Step-down transformers

The transformers shall be of three-phase, oil-immersed self-cooled, outdoor use type with off-load tap changes and frequency shall be 50 Hz.

The following transformers shall be supplied:-

- 11 kV/400 - 230 V	75kVA	1 unit
	50kVA	1 unit

The primary windings shall be connected in delta. The secondary windings shall be connected in wye and the neutral terminal shall be provided outside the tank.

(i) Temperature rise

The maximum temperature rise shall not exceed

(1) 50°C in oil by thermometer and

(2) 55°C for winding by resistance measurement.

(ii) Insulating oil

Insulating oil shall be of non-sludging and of medium viscosity. All transformers shall be supplied with oil filled.

(iii) Connection

The connection of the transformer windings shall be as follows.

Primary	Secondary
Delta	Star

(iv) Windings and insulation level

The windings shall be of high conductivity copper. The windings shall be fully insulated and the basic impulse insulation level of the primary side of the transformer shall be 150 kV.

(v) Taps and tap changers

The transformers shall have taps, which are changeable under no voltage, on the primary side thereof, so as to cover a range of +5% to -10% of the rated voltage at steps of 2.5%.

Transformers shall be provided with tap changer handles outside the transformer tanks.

(vi) Bushings

Bushings shall be of brown or other approved colour solid type, and the Contractor shall provide clamp type terminals for the bushings.

(vii) Accessories

- Earthing devices

Earthing devices shall be supplied for grounding of distribution transformers and also for grounding of lightning arresters. The devices shall consist of the following:

(a)	Earthing rod	:	Covered by copper, 1.5 m length
(b)	Lead terminal	:	C-type clamp
(c)	Lead wire	:	IV 38 sq.mm, 11 m length
(d)	Protection cover	:	16 mm dia pipe, 3 m length

- Earthing rod shall be of steel and covered by copper.

- Each transformer shall have the following accessories.

(a) Lifting lugs
(b) An oil level indicating tube or window
(c) An earthing terminal
(d) An earthing terminal
(e) Mounting fixture on the type T pole
(f) A name and rating plate

(Note)
The capacity value of the transformer shall be clearly marked the transformer case in adequate size.

(viii) Spare parts

The following spare parts shall be supplied with the transformer.

(a) 5 nos. for each type of HT bushings

(b) 10 nos for each type of LT bushings

(b) Lightning arresters

Lightning arresters shall be of outdoor use, valve type or gapless type and shall have suitable mounting fixtures on the cross arms. Each arrester shall have clamp type terminals for ACSR 58 mm^2 for the side and 38 mm^2 for grounding side respectively.

The rating of the arresters for 20 kV system shall be as follows:

Rated voltage	28 kV
Rated discharge current	5 kA

(c) Cutout switches

The 20 kV primary cutout switches shall be of outdoor use, single pole, book operated, drop out type, 24 kV, 100 A frame, and shall have suitable mounting fixtures on the arm. Switches shall have bolted type terminals for ACSR 58 mm^2. Cartridge fuses for the primary cutout switches shall be rated at 3 and 5 amperes. The Contractor shall supply suitable operating rods for the cutout switches.

(d) Distribution switch boxes

At each transformer, a distribution switch box shall be supplied. The distribution switch boxes shall be made of painted steel with key locked front doors and be mounted on tubular poles. They shall be outdoor use and incoming/outgoing cable. Outlets shall be provided at the bottom wall.

The following MCB (molded case circuit breaker) for AC 400 V circuit voltage and watt-hour meters for 3-phase 4-wire system with PT and CT, if required, shall be provided for each distribution box as additional works.

Transformer capacity	Transformer 2ry circuit	Feeder circuit
30 kVA	3-P, 100AF (75A Trip)	3 x 3-P, 50AF (30A Trip)
50 kVA	3-P, 100AF (100A Trip)	3 x 3-P, 50AF (30A Trip)

The following molded case circuit breakers shall be supplied as spares:

3-P, 50AF (30A Trip) ..... 1 no.
2-P, 50AF (30A Trip) ..... 2 nos.

T8.7.6 22 kV cubicles including 75 kVA transformer

The cubicle shall be outdoor use, metal-clad sheet steel cubicle of robust construction provided with access doors which can be key locked to prevent accidental contact with live parts.

Control switches, all necessary indication and fault annunciation shall be given on the swing panel board in the cubicle. The access doors shall have a sheet of clear glass for supervision.

The outdoor cubicles shall consist of the following:

(a) 1 - incoming (receiving) line cubicle
(b) 1 - transformer cubicle

(a) Incoming line cubicle

The cubicle shall be mounted with the following:

(i) 1 set - metering outfit with watthour and demand meters
(ii) 1 set - main busbar (insulated)
(iii) 1 set - main busbar (insulated)
(iv) 2 sets - fluorescent lighting fixtures, 20W × 1
(v) 1 set - convenience outlet, 2P, 250V, 10A
(vi) 1 set - space heater with thermo-regulating switch
(vii) 1 set - terminals and other necessary apparatus
(vii) 1 lot - necessary accessories

(b) Transformer cubicle

This cubicle shall be provided for the distribution transformer. All necessary indication and no-fuse breakers shall be provided on the swing panel in the cubicle. The cubicle shall be mounted with the following.

(i) 1 - fused disconnecting switch, 24 kV, 600A, fuse 10A

(ii) 1 set - main busbar (insulated)

(iii) 1 set -transformer, 3 phase, 20 kVA, 22 kV/400 - 230V

(iv) 1 - grounding potential transformer, 3 phase, 22 kV/100V/$\frac{11}{3}$V

(v) 1 - undervoltage relay

(vi) 1 - A.C. voltmeter, 0 - 25 kV

(vii) 1 - voltmeter changeover switch

(viii) 1 - ground overvoltage relay

(ix) 1 - three phase potential transformer, 400/110V

(x) 1 - A.C. voltmeter, 0 - 500V

(xi) 1 - voltmeter changeover switch

(xii) 1 - single phase current transformer, 50/5A

(xiii) 1 - no-fuse breaker, 4-pole, 550V, 50 AF

(ivx) 2 - no-fuse breakers, 3-pole, 550V, 30 AF

(vx) 2 - no-fuse breakers, 3-pole, 250V, 30 AF

(vix) 2 sets - fluorescent lighting fixtures, 20W × 1

(viix) 2 sets - convenience outlets, 2P, 250V, 10A

(viiix) 1 set - space heater

(ixx) 1 set - cable ends

(xx) 1 set - terminals and other necessary apparatus

(xxi) 1 lot - necessary accessories

(c) Particular of cubicle apparatus

Particulars of main component equipment of the cubicle specified in this Clause shall be as given hereunder:

(i) 22 kV fused disconnecting switch - the fused disconnecting switch shall be of indoor, three poles, single throw and mechanically hand operated type with fuse element and necessary accessories and ratings shall be as follows:

- Rated voltage : 24 kV
- Rated current : 600A
- Rated fuse element : 5A

The load break switches with power fuse will be acceptable on the condition that the switch can interrupt the existing current of the 20 kVA transformer.

The operation rod for the disconnecting switch shall be supplied as accessories.

(d) Particular of outdoor apparatus oat 20 kV power cable connection point

Particulars of outdoor apparatus specified in this Clause shall be as given hereunder:

(i) 22 kV lighting arrestors - The lightning arrestors shall be of outdoor use, gapless type with suitable fittings for mounting on the distribution line pole and the ratings shall be as follows:

- Rated voltage : 28 kV
- Rated discharge current : 5 kA

Each arrester shall have clamp type terminals for ACSR of 58 mm^2 for the line sides and for copper wire of 38 mm^2 for the grouting side.

T8.8 Emergency Power Supply System

T8.8.1 General

One 75 kVA diesel engine generator set with necessary switchgear, accessories, panels and materials for installation shall be furnished as a emergency power source to supply electric power for operation of river outlet valve and intake gates. Single line diagram and block diagram of power supply system are shown on the Drawings.

Equipment and apparatuses including panels to be specified in this item shall be tested at manufacturer's factory in the presence of the PMO/Engineer, according to the applicable standards before shipment.

All panels and wires shall be marked near each terminal end with colored end caps according to Clause T8.3 of this Specifications.

Recommended spare parts for this item shall be furnished in addition to spare parts to be supplied under this item.

T8.8.2 Diesel engine generator set

(a) Diesel engine

The diesel shall be of electric D.C. motor starting, vertical cylinder, single acting, 4-cycle, solid injection, water cooled type with radiator, forced lubrication system.

Engine cylinder liners shall be of the full length, replaceable cast iron type.

The engine shall not require premium fuel for satisfactory performance.

The diesel engine and generator shall be placed on a common bedplate.

Continuous output of diesel engine generating set shall be guaranteed to be 60 kW at generator's terminal at an engine speed of 1,500 rpm at EL. 196.000 meter under the climatic conditions set forth in the General Specifications.

The diesel engine shall be automatically started by control in automatic starting panel, stopped automatically and locked when fault happens. The diesel engine shall be also capable of manual starting and manual stopping. D.C.-power for starting the engine shall be fed from battery.

In addition to the above, the following accessories shall be supplied for the engine.

(i) A daily fuel oil tank of 200 litre capacity with float level gauge for gravity feed to the engine together with stand.

(ii) Filters for fuel oil and lubricating oil

(iii) Mechanical type governor with throttle control button for speed control

(iv) Radiators and radiator fan

(v) Common bedplate, foundation bolts and nuts

(vi) Reamer bolts with nuts, for coupling up with generator

(vii) Alarm and automatic shut down device in the event of lubricating oil pressure drop and cooling water high temperature

(viii) Panel for safety device with alarm, associated with the generator panel.

(ix) Lubricating oil pressure gauge

(x) Thermometer for cooling water temperature

(xi) Tachometer

(xii) Starting motor

(xiii) Air suction strainer, cleanable type to avoid frequent replacement

(xiv) All piping materials with valves and cocks

(xv) Expansion or flexible joint for exhaust pipe

(xvi) Maintenance tools and manufacturer's standard spare parts

(xvii) 150% of the quantity of lubricating oil to be required

(xviii) Silencer and exhaust pipe to atmosphere

(xix) Special tools for erection and repair (including I-beam & chain block)

(xx) Exhaust duct

(xxi) Any additional accessories to manufacturer's standard

(b) Generator

The generator shall be 3-phase, 4-wire, revolving field type with damper winding, self-excited, self-ventilated open type, of brushless excitation system, synchronous alternator with generator panel.

The rating of the generator shall be 40/230 V, 50 Hz, 0.8 lagging, 60 kW maximum continuous output and shall be directly connected and flange mounted to engine.

Insulation shall be Class "F".

The brushless excitation system shall consist of AC exciter, rotating rectifiers and solid state type automatic voltage regulator capable of controlling voltage within ±2.5%from no-load to full-load.

The generator panel shall be of unit mounted type and consist of molded case circuit breaker, current transformers, automatic voltage regulator and instruments such as A.C.-voltmenter, A.C.-ammeter with selector switch, frequency meter, emergency engine stop button and other manufacturer's standard accessaries.

The neutral point of armature winding will be connected to the neutral bus of the panel and solidly grounded.

T8.8.3 D.C. power panel

D.C. power panel shall be of self-standing type, having doors in front to facilitate inspection, and consist of battery charger and battery complete with control devices and wires.

Battery charger shall be provided with molded case circuit breakers, shunts and rectifier element. The rectifier element for the battery charger shall be of silicon (selenium and mercury type not acceptable). The battery charger shall be controlled from the front panel. Fuse protection shall be provided for individual rectifier diodes.

The battery charger shall be capable of initial charging, floating operation and equalizing charging for 100 AH storage battery. The battery charger shall be equipped with an automatic voltage regulator to maintain D.C. output voltage within ±2% under operating condition.

The battery charger shall be designed for the following requirements.

A.C. input voltage..... 230 volt - single phase
Rated D.C. output voltage..... 24-volt
Rated D.C. output current..... 20-amp.

The battery charger shall include but not be limited to the following:

1 set	-	rectifier element
1 set	-	automatic voltage regulator and necessary accessories
3 sets	-	molded case circuit breakers for protection of D.C. power supply system
3 sets	-	molded case circuit breakers for auxiliary D.C. power service
1	-	volt meter with selective switch
2	-	ammeter with shunts
1	-	D.C. ground relay

1 - D.C. undervoltage relay

4 - lamp indicators for fault alarm, source, float charge and equalizing charge

1 - change-over switch for float charge and equalizing charge

Storage battery consisting of 20 cells each in sealed plastic transparent container shall be of Nickel Cadmium alkaline vented type, 24-volt, 100 amp-hour at 5-hour discharge rate, coordinated with the battery charger to supply D.C. power to the diesel engine and auxiliary devices.

The battery shall be provided with the following:

(i) Positive and negative sintered plates consisting of highly porous nickel plaques

(ii) Alkali-resistant synthetic separators

(iii) Cells of enclosed alkali-resistant type, consisting of chemical resisting material, with provisions for measuring the specific gravity of electrolyte from outside

(iv) Cell terminal post

(v) Alkali-resistant painted steel battery rack

The following accessories shall also be supplied under this Clause:

(i) Requisite quantity of potassium hydroxide with 10% extra

(ii) Sufficient quantity of distilled water for first filling up

(iii) Mixing tank of adequate capacity

(iv) Voltmeter, portable hydrometer and vent mounted thermometer

(v) Intercell connectors between cells and terminal lugs

(vi) 100% of actual use of diluted potassium as spare

(vii) 100% of actual use of distilled water as spare

T8.8.4 Automatic starting panel

Automatic starting panel shall be of self-standing, cubicle type and contain necessary control and indicating equipment including control cables (Type CVV) to automatically start the diesel engine generator and automatically transfer the load from the commercial power to the diesel engine generator when the line voltage drops to 70% of the normal value, and transfer the load back to the load from the generator when the generator voltage is reached to 90% of the normal value.

Change-over switch shall be provided for auto-manual operation of the transfer switch.

The transfer switch shall be of 4-pole, 550-volt, 200 amp. electrically operated type. Ammeter, voltmeter with selector switch, current transformer, voltage relay, bell, buzzer, status indicators, fault indicator start-stop button, name plates and change-over switch for auto-manual operation of diesel engine generator shall also be provided in the panel.

Suitable means shall be provided for diesel engine starting failure to open the starting circuit after about 45 seconds from the charging.

Apparatuses and accessories to be mounted on the automatic starting panel shall be satisfactorily operated and completely coordinated with the generator panel.

T8.9 Grounding System

T8.9.1 General

The Contractor shall furnish apparatuses and materials necessary to complete the grounding system as shown on the Drawings. The target grounding resistance shall be 10 ohm or less for the high voltage switchgear and 100 ohm or less for low voltage switchgear.

T8.9.2 Grounding materials

The Contractor shall furnish the following materials.

(a) Bare annealed copper conductor:- main grounding conductor shall be 100 mm^2 and the other 38 mm^2.

(b) Grounding plates:- grounding plates shall be 3 mm thick by 1 m x 1 m and equipped with copper lead conductor of 100 mm^2 for connection with main grounding mesh.

(c) Compression type wire connectors.

(d) Steel copper clad grounding rods (25 mmø x 2 m)

(e) Grounding terminal boxes made of sheet metal, with removable cover and copper terminals

(f) Tools

T8.10 Dam Leakage Water Drainage System

T8.10.1 Pumping equipment

(a) General description

The arrangement of the equipment for the dam drainage purpose shall be as shown on the Drawings.

(b) Description

The following principal items shall be included:

(i) Two submersible type drainage pumps
(ii) Pump discharge pipework, valves and pipe bends
(iii) Supports for pumps, pipework, valves, etc.
(iv) Pump handling equipment
(v) Submersible mixer

The dam drainage pumps shall be situated in a chamber leading from the inspection gallery at the lowest part of the dam (EL. 105.70).

The two submersible pumps shall draw the dam seepage water from the sump pit and discharge it through insitu pipework by way of the inspection gallery to drain ditch in the inspection gallery at level EL. 160.00.

(c) Drainage pumps

Two (2) sets of motor driven submersible type pumps for stationary installation are to be provided complete with cabling. The pumps shall be of approved type. The motors shall be suitable for direct-on-line starting.

The capacity of each pump shall be approximately 400 liters per minute, the maximum static delivery head being 54.3 m to which must be added the pipe losses.

The pumps shall be installed as indicated on the Drawings and shall be capable of operation in the seepage water from the dam. Particularly during the early working life of the pumps, this seepage water is liable to become alkaline due to the presence of chemical salts from the concrete or cement grouted rock foundations of the dam during initial impounding. Consequently, the general design of the pumps shall be such as to ensure continued working in the event of encrustations forming in the water passages, and to enable each pump to be easily stripped down for cleaning and maintenance.

Impellers shall be approved chrominum-alloy cast iron. All water passages shall be finished smooth.

Pump casings shall be fitted, where necessary, with renewable rings of suitable materials at the points of running clearance. Casings shall be of cast steel of approved grade or cast iron.

Pump shafts shall be of corrosion resisting steel unless contact with water is precluded. The rotating and stationary wear rings in the lower seals shall be of sealing tape for long life.

The upper and lower bearings shall be of the roller and double row angular contact ball type respectively. They shall have sufficient grease for at least three years continuous service.

The motor junction boxes shall be of the submersible type with water-proofing cabling or sufficient length to connect into the isolating boxes mounted above the free flow flood level EL. 130.00.

Each pump shall be provided with pipework, flanges and valves.

The pumps shall be automatically controlled to start in sequence as the water level in the sump rises and to stop in a similar way as the water level falls. Water from the sump shall be pumped up to the inspection gallery at the level EL. 160.00.

The pumps shall be automatically operated under the following conditions:

(i)	Pit filling	Sump pit water level
	Duty pump starts	106.90 m
	Standby pump starts	107.20 m
	High water level alarm	107.70 m

(ii) Pit emptying

High water level alarm resets	107.65 m
Standby pump stops	107.20 m
Duty pump stops	106.70 m

One control panel shall be located in the main control house. All necessary instruments and controls to suit above requirements shall be contained in the control panel. Manual operation shall also be made by push-button controls with change-over switches. An alarm system shall be provided to detect high water level in the pit and to give warning to the dam control house.

The pump sets shall pass such tests as are required in the relevant standards.

(d) Pipework and valves

All galvanized drainage pipe approved by the PMO/Engineer shall be flanged and provided complete with all necessary non-return valves (check valves), stop valves, air relief valves, pipe brackets and supports, anchors, erection fittings, bolts, gaskets, etc.

The pumps, pipework, and valves shall be designed to safely withstand all static, hydraulic, pumping and water hammer pressures and stresses imposed during any operation or possible mal-operation of the pumps.

(e) Non-return valves

The non-return valves (check valves) at the pump discharge flanges shall be of the conventional swing check type. The body, door and cover shall be of cast iron of similar with bronze seals and bronze pin.

(f) Pump supports etc.

All necessary steel supports for the drainage pumps, valves, pipework discharge bends, etc., complete with suitable holding down bolts shall be provided.

(g) Submersible mixer

One electrically driven submersible mixer, approximately 1 kW, complete with three-bladed propeller, cabling, glands, support tube, indexing plate and top mounting bracket shall be provided. This shall be suitable for direct-on-line starting and capable of operating in the seepage water from the dam. The motor junction box and cable shall be of similar duty to that specified for the drainage pumps, the cable also being terminated at an isolating box above level EL. 130.00.

(h) Pump handling equipment

One (1) set of manually operated geared travelling chain block, 1 ton capacity, complete with steel supports and its anchored rail shall be provided for the maintenance of pumps and submersible mixer.

T8.10.2 Paint schedule

One epoxy resin zinc rich primer coat and two or three coats of coal-tar epoxy resin paint, total film thickness of 0.45 - 0.60 millimeters, shall be applied to the following items:

Drain pumps
Non-return valves
Submersible mixer
Pipe brackets and supports
Pump handling equipment

When galvanizing has been damaged, the area affected shall be cleaned and coated with approved zinc-rich paint or zinc metalling.

T8.11 Measurement and Payment

Measurement for payment for the supply and installation of electrical works will be made on the actual installed number as follows:

(1)	Panelboards	:	measured in set
(2)	Lighting fixtures	:	measured in set
(3)	Wires and cables	:	measured in meter
(4)	Joint and pull boxes	:	measured in set
(5)	Tumbler switches	:	measured in set
(6)	Receptacles	:	measured in set
(7)	Conduits	:	measured in set
(8)	Handhole	:	measured in set
(9)	DG set	:	measured in set
(10)	Drainage pump	:	measured in set
(11)	Grounding wire	:	measured in meter

(12)	Grounding rod and plate	:	measured in set
(13)	Distribution line conductor	:	measured in meter
(14)	Distribution line pole assembly	:	measured in set
(15)	Step-down transformer	:	measured in set

Payment will be made on the length or numbers measured as provided above at the unit prices stated in the Bill of Quantities which unit prices shall constitute full compensation for the cost of all labors, tools, apparatuses, equipment and materials including those for the tests, excavation, backfill and other items necessary to complete the work.

Payment for items not mentioned here will be made at the unit prices stated in the Bill of Quantities and by the same manner as described above.

CHAPTER T9 MISCELLANEOUS METALWORKS

T9.1 General

These Specifications cover fabrication, erection and other general requirements incidental to miscellaneous metalwork to be made in accordance with the Drawings.

The Specifications in this CHAPTER are applicable to all metalworks unless otherwise specified in CHAPTER T6, BUILDING WORKS.

The Contractor shall perform all miscellaneous metalworks as shown on the Drawings or as directed by the PMO/Engineer. Unless otherwise specifically provided in these Specifications, metals shall be manufactured, fabricated and installed in accordance with the provisions of JIS Designation or other approved equivalent.

The Contractor shall be required to prepare the manufacturing or shop drawings showing complete details, sections and plans of all parts, assemblies, materials lists, components, connections and supports, and relations to the structures based on the standard details and subject to the approval of the PMO/Engineer.

The Contractor shall be responsible for the correctness and completeness of the shop drawings and for shop fit and field connections, although the shop drawings have been approved by the Engineer. When structural members are fabricated by bolting, a fabrication procedure including a list of equipment to be used will be required of all fabricated, if it is deemed necessary in the opinion of the PMO/Engineer.

The work shall be shop fitted and shop assembled where possible, and shall conform to the details on approved shop drawings.

Where necessary, metal shall be insulated to prevent electrolysis due to contact between dissimilar metals and to prevent corrosion due to contact between metals and masonry or concrete. Insulation shall be by means of bituminous paint or other approved means.

All fastenings, anchors and accessories required for fabrication and erection of the work under this CHAPTER shall be provided. Exposed fastenings shall be kept to an absolute minimum, evenly spaced and neatly set out. Wood plugs shall not be permitted.

T9.2 Materials

All materials to be furnished by the Contractor shall be new and shall be of the best quality of their respective kinds and shall conform to JIS Designation or other approved equivalents as follows:

Materials	JIS Designation	
Structural steel	G 3101 - 76	(SS 41)
Structural steel for welding	G 3106 - 77	(Class 1. SM41A)
Steel bar (plain round steel)	G 3112 - 85	
Steel plate	G 3194 - 66	
Shaped steel	G 3192 - 77	
Stele deck	G 3352 - 79	
Steel tube and pipe	G 3444 - 82	(Class 2. STK41)
Steel galvanized pipe	G 3442 - 66	(SGPW)
Steel square pipe	G 3466 - 82	(Class 1. STKR41)
Steel forgings	G3201 - 78	
Steel bolt, nut and washer	G3123 - 79	
Cast iron valve	B 2031 - 84	
Cast iron shoe	G 5501	

Before purchase, samples of all materials proposed for incorporation in the works shall be submitted for the approval of the PMO/Engineer, as and when required.

T9.3 Workmanship

T9.3.1 General

Workmanship and finish shall be first class and equal to the best practice in modern fabrication and machine shops. Before laying out, cutting or fabricating the work in any way, the material shall be thoroughly straightened by methods that will not result in injury, except that sharp kinds or bends in members to be straightened will be cause for rejection. Finished members shall be free from kinds, bends, or winds.

Shearing shall be accurately done, and all portions of the work neatly finished. Corners shall be square and true unless otherwise shown on the Drawings. Bends, except for minor details, shall be made by approved bending rollers. The metal shall not be heated unless approved by the PMO/Engineer. Heating, when permitted, shall be limited to an extent up to producing a dark cherry red colour on the metal surface. Heated metal shall be gradually cooled and be subject to thorough inspection. Steel with welds will not be accepted unless otherwise welding is definitely specified on the Drawings. All bolts, nuts and screws shall be tight.

The ends of pipe, except for handrailing, shall be reamed. Holes for drainage shall be provided in such horizontal or inclined members as may be subject to retention of entrapped water, as shown on the Drawings, or as directed by the PMO/Engineer.

All joint and intersecting members shall be accurately fitted and all works shall be fabricated in true planes with adequate fastenings.

T9.3.2 Welding

Unless otherwise authorized or specified, welding shall be by the electric arc-welding process. Highly important joints and connections which will be heavily stressed in service and all fields splices shall be made with special precautions to ensure that such joints are sound and without flaws. Welding shall be subject to inspection by the PMO/Engineer.

The welding rods shall be of the heavily coated type designed for all position welding, and the size, type and manufacture of the rods shall be subject to the approval of the PMO/Engineer. Welds shall be made as specified on the Drawings. All welders shall be qualified and if in the opinion of the PMO/Engineer, the work of any welder at any time appears questionable, such a welder shall be required to pass another qualification test.

All beveling of the materials shall be done as shown on the Drawings and shall be finished to a smooth and true finish with an automatic gas cutter or grinders. The use of manual gas cutters shall be subject to the prior approval of the PMO/Engineer.

The surface of the working materials shall be free from slag, moisture, soil, rust, oil, paints and other impurities. Mill scale which can not be removed with a stiff wire brush and thin lined oil will be allowed to remain.

The face of welds shall be smooth and form a uniform beads as directed by the PMO/Engineer. And the size of beads shall not be less than the designed dimension or dimension directed by the PMO/Engineer. A slight excess over the designed dimension is permissible. However, there shall not be excessive built up or marked irregularities in the surface appearance.

Blow hole, slag, overlap, undercut and unsatisfactory melting of welded joints shall be removed with grinders or gas gaugings with due care to protect the surrounding part from any injuries or damage and then shall be rewelded. Deformation of the members resulted from welding shall be repaired in a mechanical method approved by the PMO/Engineer. Heating temperature for correcting deformations shall be less than about 650°C.

T9.3.3 Riveting

Punching, drilling, reaming and riveting shall be in accordance with the best commercial practice for the type of work concerned and as approved by the PMO/Engineer.

T9.3.4 Unfinished bolt connection

Connection by unfinished bolts shall not be used for the structural members which are subject to heavy stresses in service.

T9.3.5 High tensile bolt connection

Unless otherwise specified or approved by the PMO/Engineer, field connection shall be with friction type high tensile bolts.

Holes for the bolts shall be not more than 1.5 mm larger than the nominal diameter of the bolt.

Deviation of the bolt holes from the alignment shall be adjusted by a mechanical reamer. Adjusting by driving drift pins shall not be permitted.

Friction surface of the members shall be cleaned as specified hereafter and shall be straight, free from warps, bends, dents, etc.

The bolt shall be tightened either by the torque wrench or the impact wrench suitable for the service to the designated torque in JIS.
Air or oil pressure for the tightening equipment shall be kept constant and adjusted whenever required.

The wrench shall have a device to put a mark on the bolt ends automatically when the required tightening has been obtained.

Tightening work shall be performed in a suitable sequence and in two steps; temporary tightening and final tightening. The final tighening shall be performed after all alignment of the members has been achieved.

After the final tightening work, it shall be tested by the Contractor by the calibrated torque wrench as directed and in the presence of the PMO/Engineer. At least 10% of the whole number of bolts shall be tested unless otherwise directed by the PMO/Engineer. If it is revealed by the test that the bolts

tested have been failed to set, the test shall be performed for all of the remaining bolts untested of a test group and the bolts failed to set shall be successfully reset.

T9.3.6 Protection of machined surfaces

Machinie-finished surfaces shall be thoroughly cleaned of foreign matter and coated with an approved rust preventive compound prior to removal from the shop. Finished surfaces shall be protected with wooden pads or other suitable means. Finished surfaces of ferrous metals to be in bolted contact shall be washed with a rust inhibitor, and those to be exposed after installation shall be painted.

T9.3.7 Zinc coatings

Zinc coatings shall be applied to the materials as required in a manner and of a thickness and quality conform to the requirements of JIS H 8641-82, Zinc Hot Dip Galvanizings, or other approved equivalent. In all cases, where zinc coating is destroyed by cutting, welding, or other causes, the affected areas shall be regalvanized by an approved repair compound.

T9.3.8 Shop assembly

Full size drawings of the steel members at the shop shall be subject to inspection by the PMO/Engineer wherever practicable.

Any error, omission, deformity, defect, or the like in the shop assembly work shall be thoroughly corrected and remedied before despatching the steels from the shop. The Contractor shall execute temporary shop erection work wherever reasonably required to satisfy himself with the work.

The steel members shall be properly protected and bundled or put in crates for transportation against expected shocks and loads effected during transportation, loading and unloading.

There shall be no members or part of them protruding out of the bundle or the crate which may be damaged during transportation, loading and unloading.

The steel members shall be assembled in the shop to as large components as possible before despatching as the transportation conditions allow to minimize field connection work.

All steel members and assembled components shall be match-marked at the shop to facilitate smooth erection in the field.

T9.3.9 Field assembly and erection

Any serious damage in the steel members in the opinion of the PMO/Engineer found in those delivered to thee Site shall be replaced with the new ones immediately without causing delay in field assembly and erection works. Minor damage may be remedied in the field by proper method approved by PMO/Engineer.

The steel members shall be properly stock piled near the work site to facilitate easy identification and handling of the members. They shall be laid on wood or other suitable base to protect them from smear with mud.

The Contractor shall, before commencing erection, install all anchor bolts and anchor connections to an accurate alignment and elevation in accordance with details and instructions as shown on the Drawings. The Contractor shall again check the alignment and elevation of the anchor connections with the columns erected and, if necessary, move the columns and bases to the correct position as shown on the Drawings. The Contractor shall then notify the PMO/Engineer of the position of alignment, elevation and plumb of all columns and shall have approval by the PMO/Engineer, prior to grouting and embedding the bases in concrete.

The steels shall be erected true to the alignment shown on the Drawings. Temporary bracings, supports and reinforcement to a member which is likely to be deformed during erection shall be employed wherever required. The bracing, support and reinforcement and temporary bolt connection shall be strong enough to carry the load exerted by the dead load of the steel, wind and others.

Final alignment of each complete and entire section of the work between adjacent expansion joints shall be made, as far as practicable, before assembly of the next section of the work.

Any misalignment of members shall be brought to the attention of the PMO/Engineer for approval of corrective measures and all remedial work shall be performed at the Contractor's expense.

The Contractor shall be responsible for ensuring that no part of the building structures is subject to erection loads which would in any way damage, or cause permanent distortion to, that part or any other part of the structure.

The Contractor shall do the work of erection under ordinary job conditions and not necessarily those which he considers most desirable. Inclement weather, work carried on by others in the immediate vicinity, the necessity of moving materials from storage to the site of erection, and all other

circumstances characteristic of construction work, are to be expected and shall not be the basis for a claim for extra compensation.

The Contractor shall take necessary safety measurements to protect the steels, workmen, equipment, property of not only his but other parties to the satisfaction of the PMO/Engineer.

T9.3.10 Painting and cleaning

All steel surfaces to be painted shall be cleaned of loose mill scale, loose rust and other foreign matter by approved mechanical means. Oil and grease deposit shall be removed by solvents. The friction surface for high tensile bolt connection shall not be painted but shall be cleaned in the same manner.

Immediately after fabrication, all ungalvanized steel surfaces, unless otherwise provided in these Specifications, shall be cleaned and a shop 2 coats of approved red lead primer paint shall be applied without delay to yield a 0.05 mm minimum dry thickness.

The final 2 coats of approved oil paint shall be applied to exposed surfaces of metal at site. The minimum dry thickness of each coat of paint shall be more than 0.1 mm.

T9.4 Embedded Metalwork

The Contractor shall furnish and install miscellaneous embedded metalwork including, but not limited to, metalwork as listed in this Clause and miscellaneous embedded metalwork as shown on the Drawings or as directed by the PMO/Engineer.

a. embedded metal frames for duct cover, manhole cover, hatch cover, grating and pump intake trashracks.
b. anchoring and handling hooks including turn-buckle anchors.
c. traps.
d. steel pipes for air vent, cable duct, water level gauging well, inlet pipe and drain.
e. rails for hatch cover and stoplog wagon
f. sole plates and bearing plates, rail crip with nuts and hooks.
g. metal safety treads for concrete stairs.

T9.5 Non-embedded Metalwork

The Contractor shall furnish and install miscellaneous non-embedded metalwork including, but not limited to, metalwork as listed in this Clause and miscellaneous non-embedded metalwork as shown on the Drawings or as directed by the PMO/Engineer.

a. non-embedded supporting structural framework and manhole covers, hatch covers, gratings, cable trench cover and duct covers.
b. steel stairs and ladders.
c. non-embedded channels and angles for holding brick or block walls.
d. screens for pump intake and leakage measuring chamber.
e. look for metal products.
f. handrails.
g. V-notched narrow crested weir

T9.6 Measurement and Payment

T9.6.1 Structural steelwork

Measurement for payment of structural steelwork will be made on the basis of the actual installed weight of structural steel in kilogram determined by the approved Drawings or directed by the PMO/Engineer.

Payment will be made for kilogram measured as provided above at the respective Contract unit prices stated in the Bill of Quantities, which unit prices for structural steelwork shall constitute full compensation for the cost of all labour, tools, equipment and materials including furnishing, fabricating, transporting, installing the structural steels, preparing and submitting shop drawings and other necessary documents, and other item necessary to complete the works.

T9.6.2 Embedded metalwork or non-embedded metalwork

Measurement for payment of embedded metalwork and non-embedded metalwork will be made on the basis of actual installed weight of embedded metal or non-embedded rated in kilogram determined by the approved Drawings or directed by the PMO/Engineer. Payment shall be made for kilogram measured as provided above at the respective Contract unit prices stated in the Bill of Quantities, which unit prices for embedded metalwork or non-embedded metalwork shall constitute full compensation for the cost of all labor, tools, equipments and materials including furnishing, fabricating, transporting, installing the embedded metal or non-embedded metal, preparing and submitting manufacturing drawings and other necessary documents, and other items necessary to complete the works. Unless otherwise specified or directed by the PMO/Engineer, the cost of

painting for embedded metalwork and non-embedded metalwork shall be included in the respective Contract unit prices as specified above.

T9.6.3 Guardrail of fence

Measurement for payment for guardrail or fence will be made of the installed length of guardrails or fence in linear meter determined by the approved Drawings or the direction of the PMO/Engineer.

Payment shall be made for the installed length of guardrails or fence at the respective unit price stated in the Bill of Quantities, which unit prices shall constitute full compensation for the cost of all labour, tools, equipments and materials including furnishing, fabricating, transporting, installing, preparing and submitting necessary documents, and other items necessary to complete the works. Unless otherwise specified or directed by the PMO/Engineer, the cost of painting and all work and materials for foundation excavation, gravel bedding and foundation concrete for guardrails shall be included in the respective unit prices as specified above.

T9.6.4 Steel pipe

Measurement for payment for steel pipes will be made of the installed length of steel pipes in linear meter determined by the approved Drawings or the direction of the PMO/Engineer.

Payment shall be made for the installed length of steel pipes at the respective unit price stated in the Bill of Quantities, which unit prices shall constitute full compensation for the cost of all labour, tools, equipments and materials including furnishing, fabricating, transporting, installing, preparing and submitting necessary documents, and other items necessary to complete the works.

T9.6.5 Hook

Measurement for payment for hooks will be made on the basis of the number of installed hooks per set determined by the approved Drawings or the direction of the PMO/Engineer.

Payment shall be made for the number of hooks at the respective unit price stated in the Bill of Quantities, which unit prices shall constitute full compensation for the cost of all labour, tools, equipments and materials including furnishing, fabricating, transporting, installing, preparing and submitting manufacturing drawings and other necessary documents, and other items necessary to complete the works.

T9.6.6 Cast iron valve

Measurement for payment of cast iron valve will be made on the basis of the number of installed valves per set determined by the approved Drawings or the direction of the PMO/Engineer.

Payment will be made for the number of valves at the respective unit price stated in the Bill of Quantities, which unit prices shall constitute full compensation for the cost of all labour, tools, equipment and materials including furnishing, fabricating, transporting, installing, preparing and submitting manufacturing drawings and other necessary documents, and other items necessary to complete the works. Unless otherwise specified or directed by the PMO/Engineer, the cost of painting shall be included in the respective unit prices as specified above.

T9.6.7 Painting for structural steelwork

Measurement for payment of painting for structural steelworks will be made on the basis of the actual painted area of the structural steel in square meter determined by the approved Drawings or directed by the PMO/Engineer.

Payment will be made for the number of square meter measured as provided above at the Contract unit price stated in the Bill of Quantities, which unit price of painting for structural steelwork shall constitute full compensation for the cost of all labor, tools, equipments and materials including furnishing, transporting, coating the paint for structural steel and other items necessary to complete the works.

T9.6.8 V-notched narrow weir

Measurement for payment of V-notched narrow weir will be made on the basis of the number of installed area of weir crest plate determined by the Drawings or the direction of the PMO/Engineer.

Payment will be made for the number of square meter measured as provided above at the Contract unit price stated in the Bill of Quantities, which unit price shall constitute full compensation of the cost of all labour, tools, equipment and materials including furnishing, transporting, installing and other items necessary to complete the work.

CHAPTER T10 MEASURING APPARATUS

T10.1 Scope

T10.1.1 General

These Specifications cover furnishing and installing measuring apparatus in the dam, its foundation and recording and data processing system as shown on the Drawings or as otherwise approved by the PMO/Engineer.

The measuring apparatus of the dam and its foundation shall comprise:

(1) Pore pressure meters in the dam embankment and foundation,

(2) Earth pressure meters in the dam embankment,

(3) Multi-layer settlement meters in the dam embankment,

(4) Surface displacement survey points,

(5) Leakage measuring facility in the downstream toe of dam embankment,

(6) Water level detector and indicator with water level gauge staff,

(7) Recording and data processing system such as data acquisition controller and personal computer including exclusive auxiliaries of printer, plotter, A.C. stabilizer, etc., and

(8) Reference points for sediment monitoring.

The Contractor shall submit, within sixty (60) days from the Award of Contract, the detail specifications on and the detail installation plan of the measuring apparatus to be furnished and installed by the Contractor for approval of the PMO/Engineer.

Alternative measuring apparatus and installation methods will be considered for approval, if being. Such alternatives shall be submitted to the PMO/Engineer and subject to the approval of the PMO/Engineer.

The work shall be performed so as to result in a minimum of interference with embankment construction operations and will include, but is not limited to, the following :

1) Apparatus shall be installed by the Contractor under the supervision of the PMO/Engineer in accordance with detailed specification furnished by the equipment manufacturer and requirements herein specified. The Contractor shall install all materials required incidental to the installation of apparatus and perform all the works required for the completion of the measuring system.

2) The Contractor shall maintain the apparatus in satisfactory operation during embankment construction. At Contract completion, the measuring system shall be repaired or replaced as may be necessary and left in satisfactory operating conditions.

3) The Contractor shall furnished such assistance as the PMO/Engineer requires for the taking of observations with the apparatus. These services will include removal and replacement of barricades and/or other protective means; for the extension of system as required; and for the diversion of construction operations locally to minimize their effect on observation. These services shall be furnished periodically and/or intermittently at such times as the PMO/Engineer may direct.

4) Extra unassigned pipes and cables shall be provided in trenches as replacement, should the original installation become damaged or inoperative during the lifetime of the measuring system.

T10.1.2 Installation of apparatus

Installation of apparatus in the dam embankment shall be made by the Contractor as embankment construction progress to the lines and elevations as shown on the Drawings, in the presence and under supervision of the PMO/Engineer. Apparatus and associated pipes, cables and other transmitting media shall be installed during the daylight hours or at night only if adequate lighting is provided as approved by the PMO/Engineer.

It shall be the Contractor's responsibility to complete such installation as soon as possible so that manual and automatic recording devices can be placed in the dam control house, and so that measuring can be made when the embankment is raised.

No portion of any apparatus shall be covered until tested and approved by the PMO/Engineer. Pipes shall be pressure tested; all leaks shall be immediately repaired. Open ends of all incomplete lines of piping shall be sealed to exclude foreign matter.

Splicing of cable will be permitted only upon approval of the PMO/Engineer. Splicing, where approved, shall be done in accordance with the manufacturer's recommendation. Materials and equipment for splicing electrical cable shall include a suitable vulcanizer. Cable shall be tested for electrical continuity and resistance; all lack of continuity and improper joints disclosed by these tests shall be immediately repaired. Each complete system shall be tested and repaired if necessary.

It shall be the Contractor's responsibility to protect the apparatus from damage or displacement during the prosecution of the work.

Any damage or displacement of the apparatus or facilities caused by the Contractor's operations shall be repaired and/or replaced by the Contractor and no additional payment will be made therefor.

All cable, pipes and other transmitting media shall be adequately marked at a maximum spacing of 15 m, and at all changes in direction to ensure that such items are kept in proper order and sequence as they are extended through the dam embankment to the manual or automatic recording devices in the dam control house.

Cables, pipes and other transmitting media shall be supplied on spool or reels when feasible at the point of installation to aid in maintaining the proper order and sequence and to minimize the need for splicing.

No traffic or equipment shall be allowed to pass over any part of an internal apparatus installation until that part is covered by a minimum of 45 cm of compacted embankment.

T10.2 Pore Pressure Meter

T10.2.1 General

The pore pressure meter shall be of strain gage type and embedded in the core zone and filter zone in the dam embankment and in the foundation as shown on the Drawings or as directed by the PMO/Engineer.

T10.2.2 Requirement

The Contractor shall furnish and install pore pressure meters with the following requirements or equivalent approved by the Engineer.

1) Rated full scale/range of measuring pressure : 2.5, 10 (kgf/cm^2)
2) Input-output resistance : 350 ohm

3) Output voltage : 1.5 m V/V

4) Nonlinearity : 0.3 % R.O.

5) Maximum diameter : 30 mm

The lead cable used for connecting the pore pressure meter to the relay terminal boxes and converter (which will be installed in the inspection gallery beneath the core zone, near the abutment of the spillway bridge and at the entrance of No.2 grout tunnel) shall be chloroprene cabtyre cable in the foundation and chloroprene cabtyre cable (heavy duty) in the embankment with enough protection against cutting, twisting and corrosion.

The lead cable used for connecting the relay terminal boxes and converter with the data acquisition controller shall be multi core cable.

The cables shall conform to the following requirements or equivalent approved by the PMO/Engineer.

Requirement	Cable		
	A	B	C
1) Withstand Voltage (V/min.)	1,000	1,000	1,000
2) Min. conductor resistance (ohm/km at 20°C)	39.8	38.2	39.8
3) Max. insulation resistance (M-ohm/km at 20°C)	500	400	2,500
4) Conductor			
- nominal section (mm^2)	0.5	0.5	0.5
- outer diameter (mm)	0.9	1.0	1.5
5) Thickness of separator (mm)	0.6	0.6	0.6
6) Thickness of rubber (mm)	0.5	0.5	0.5
7) Thickness of vinyl film (mm)	0.05	0.05	-
8) Thickness of anti-cosrosive polyvinyl chloride sheath (mm)	1.4	1.3	1.8

Note ; A : Chloroprene cabtyre cable

B : Chloroprene cabtyre cable (heavy duty)

C : Multi core cable

Relay terminal boxes shall conform to the following requirements or equivalent approved by the PMO/Engineer.

1) Switching channel : 12 or 24

2) Power source : A.C. 100V/200V ± 10%, 50/60 Hz

3) Material : stainless steel

The Contractor shall furnish other media required to transmit pore pressure to the recording and data processing system set in the dam control house.

T10.2.3 Installation

(1) In embankment

Prior to installation of pore pressure meters and cables, or other transmitting media, trunk and offset trenches shall be excavated and selected sand shall be placed in the trench bottoms.

The meters shall be placed upon the selected material in accordance with the manufacturer's approved specifications. No pockets of loose material will be permitted adjacent to the meters or connecting cables.

Excavation of trenches shall be to such depth as to provide for a minimum thickness of selected bedding material, and to widths as required for cabling of the meters and such other apparatus as may be installed in the same trench.

Trench depths exceeding 1.5 m and reversals of grade will not be permitted.

Excavation of trenches for the meters shall be done by hand methods so as to disturb the adjacent embankment as little as possible.

Cables for the meters shall be bedded in selecting fine grained material to prevent during backfilling and subsequent construction.

A minimum bedding thickness of 20 cm will be provided around all cable.

(2) In foundation

The Contractor shall drill boreholes with a diameter of 66 mm to the elevation at the designated spot as shown on the Drawings or as approved by the PMO/Engineer and flush with water until it becomes clean. The pore pressure meters to be installed in the foundation shall be inserted to the hole and set on the bottom of the hole. The meter assembly shall be composed of the meter (transducer), washed selected sand, a synthetic textile bag and tie string. The bottom portion of the hole shall be backfilled with the some selected sand for about 1m. The upper remainder of the hole shall be backfilled with mortar grouting to be watertight.

(3) Manufacturer's specifications

All procedures for installing each meter shall conform to the manufacturer's specifications approved by the PMO/Engineer.

T10.3 Earth Pressure Meter

T10.3.1 General

The pore pressure meter shall be of strain gage type and embeded in the core zone in the dam embankment as shown on the Drawings or as directed by the PMO/Engineer.

T10.3.2 Requirement

The Contractor shall furnish and install earth pressure meter with the following requirements or equivalent approved by the PMO/Engineer.

1)	Rated full scale/range of measuring pressure	: 2 kgf/cm^2
2)	Input-output resistance	: 350 ohm
3)	Output voltage	: 1.0 m V/V
4)	Nonlinearity	: 1.0 % R.O.
5)	Maximum diameter	: 100 mm

The lead cable for connecting the earth pressure meter to the relay terminal box (which will be installed near the abutment of the spillway bridge) shall be chloroprene cabtyre cable (heavy duty) with enough protection against cutting, twisting and corrosion.

The Contractor shall furnish other media required to transmit earth pressure to the recording and data processing system set in the dam control house.

T10.3.3 Installation

A pit shall be excavated to 20 cm above the designated elevation where the meter shall be embedded in the designated spot. The pit shall have a bottom area of 1.5 m square and a slope of side walls 1 vertical to 1 horizontal and a side of bottom square shall be parallel with the dam axis. The depth of the pit shall not be less than 1 m. At the bottom of the pit, a trench, 50 cm wide at the bottom and 1 m long ,shall be excavated to the 30 cm deep parallel with the dam axis. The bottom of trench shall be finished horizontal and the side wall shall be finished smoothly to have a slope of 45 degree. The embankment material passing No. 10 sieve (i.e 2 mm opening) shall be placed in the trench and

compacted to the same compaction degree as that of the surrounding embankment materials and finished to be horizontal at the bottom and to have a slope of 45 degree at both side walls with 10 cm thick.

T10.4 Multi-layer Settlement Meter

T10.4.1 General

Crossarm gage type multi-layer settlement meter shall be furnished to measure the internal vertical displacement of the dam embankment, as shown on the Drawing or as directed by the PMO/Engineer.

T10.4.2 Requirement

The cross gage type multi-layer settlement meter shall consist of a series of telescoping pipe sections with alternate sections anchored to the embankment by horizontal steel channel crossarms at 10 m intervals.

The crossarms shall ensure that the pipes move together an amount equal to compression of the intervening fill. Depths to the measuring point at the lower end of each interior pipe shall be sounded to the nearest (3 mm) by a probe with spring - loaded sensing pawls, lowered on a steel tape.

The probe shall be lowered just beyond each interior pipe in turn and raised until the pawls latch against the lower end. On reaching the bottom of the pipes, the pawls shall retract and lock within the body of probe.

Each pipe shall conform to the following.

(1) Foundation pipe

The foundation pipe to be connected in a desired length with a latching plate shall be installed at one joint and anchored with mortar in a hole drilled in the upper slab of the inspection gallery.

The bottom pipe shall be attached with a cap for preventing the foreign matter.

(2) Settling pipe

The settling pipe shall move together an amount equal to compression of the intervening fill, being fixed with the crossarm made of a channel steel at right angles at the middle of the pipe.

(3) Intermediate pipe

The intermediate pipe shall be connected with a settling pipe in telescoping.

(4) Upper pipe

The upper pipe identical to an intermediate pipe shall be used to extend an access pipe up to the surface of embankment.

A plug shall be put on the top of the cable and be so waterproof as to be removed and replaced with measuring staff during the measurement.

Measuring torpedo and staff shall conform to the following or equivalent as approved by the PMO/Engineer.

1) Two (2) pieces of the measuring torpedo shall be furnished, which shall be composed of steel tape with graduated in 1 mm division.

2) Two (2) pieces of the measuring staff shall be furnished which shall be composed of requirement as below.
   - full length : 1,570 mm
   - spring balance : 20 kg
   - sub-measure : 150 mm stainless steel scale marked with two kinds of graduations, one is in 1 mm division and the other is 0.5 mm division.

T10.4.3 Installation

Installation and bedding shall conform to the manufacturer's approved instructions. The Contractor shall keep the inside of the pipes free from foreign matter during installation. Pipe extensions shall be carried out above the completed embankment surface and concrete caps placed thereon, as shown on the Drawings or as directed by the PMO/Engineer.

T10.5 Surface Displacement Survey Points and Reference Points for Sediment Monitoring

T10.5.1 Material

Surface displacement survey points shall consist of settlement points, pairs of reference points and a levelling device.

The survey points on the crest surface shall be different from those on the slope surface, and same type of points shall be applied to the settlement points and reference points as shown on the Drawings.

The settlement and reference points on the crest surface shall be composed of a concrete pedestal of about 60 cm square and 55 cm height, about 1 m under the crest surface and a reinforcing bar of 32 mm diameter and 80 cm long with a rounded top.
The points shall be covered by concrete slab.

The settlement and reference points on the slope surface shall be composed of a pit backfilled with concrete of about 40 cm square and 160 cm depth embedded in the slope and a reinforcing bar of 32 mm diameter and 150 cm long with a rounded top.

The levelling device shall consist of a level and staff.
The level shall read the staff graduated in 1 mm or as directed by the PMO/Engineer.

The reference points for sediment monitoring, shall be installed at three (3) points on the right bank of the Profonde river and at five (5) points on the left bank of the Terre Rouge river as shown on the Drawings. They shall be composed of a concrete pedestal of about 60 cm square and 1 m height, which top of 20 cm above the ground surface.

T10.5.2 Installation

The reference points shall be installed on the rock surface or the sound ground surfaces as approved by the PMO/Engineer in the similar manner to that for the installation of the bench marks. The reinforcing bar shall be embedded vertically in the concrete pedestal so that the top portion of about 3 cm long shall be exposed.

The settlement points shall be installed between the reference points by the same manner as that of the reference points.

T10.6 Leakage Measuring Facilities

T10.6.1 General

Leakage water through the core embankment and the dam foundation will be measured in a leakage measuring chamber, which will be constructed at the downstream toe of the main dam embankment in the spoil bank as shown on the Drawings.

Leakage water staying in the sump pit in the inspection gallery will be measured by a facility consisting of a triangular weir after being pumped up through a drain channel to be constructed in the inspection tunnel.

This sub-clause specifies the former one, and a specification for the latter one consisting mainly of concrete work shall be referred to CHAPTER 4 CONCRETE WORK.

T.10.6.2 Material

The measuring facility shall be composed of an inlet block, triple screen, a triangular weir, a pit, etc. housed in a leakage measuring chamber as shown on the Drawings.

An inlet block shall be made of concrete. The area is 140 cm square and the width is 20 cm, which shall be fixed at the inlet of the measuring channel with an area of 100 cm square. The block has strainers of slit type with a slot size of 20 mm holed by 100 mm zigzag interval.

Each screen shall have 1 m square in an area with 75 mm (center to center) bar pitch.

A triangular weir with a notch angle of 90° shall have 30 cm in the notch depth to be provided around the end portion of the measuring chamber of which side walls and bottom shall be covered with steel channel having 2,500 mm in length.

A concrete pipe of 1,000 mm diameter shall be provided to divert the leakage water from the chamber to the downstream side through the slope of the spoil bank.

The leakage measuring chamber shall be made of concrete with such auxiliaries as cover plate, ladder, grating, etc. of which details will be as directed by the PMO/Engineer.

Wing walls shall be attached to the chamber at both sides up to the both abutment at elevation of EL. 121.00 m to collect the leakage water in the measuring channel.

The leakage water shall be transmitted to the recording and data processing system set in the dam control house, through a converter which shall be a signal switchover unit.

T10.7 Water Level Detector and Indicator

One (1) set of water level detection equipment with electric water level transmitter, housed in a waterproof enclosure, shall be provided in the inclined concrete step accessing to the intake facilities. The water level detector shall be of digital water level measurement sensor and shall consist of magnet float, read switch with resistor, stainless pipework of float, lighting conductor and other necessary accessories.

The water level detector shall be provided in accordance with the following requirements.

Measuring range	:	EL.193.50 m to EL.138.00 m
Accuracy	:	Less than ± 1.0 cm

The location of the water level detection equipment is as shown on the Drawings, being embedded in the inclined concrete step for travelling winch for closure of the diversion gate, and the water level measured shall be transmitted to the dam control house for display and processing.

In addition to the above, a staff gauge made of metal plate shall be set on the inclined concrete step, which shall be subjected to an approval of the PMO/Engineer. The contractor shall set the staff gauge based on accurate levelling from a designated bench mark.

T.10.8 Measurement and Payment

T10.8.1 Measuring apparatus

(1) Pore pressure meter

Measurement for payment for furnishing and installing the pore pressure meter in foundation or embankment will be made on the basis of the actual number of the pore pressure meter installed according to the Drawings and the Specifications and as approved by the PMO/Engineer.

Separate measurement and payment for furnishing and installing the joint box and cable for the pore pressure meters shall be made as stated in sub-clause T10.8.5.

Payment for furnishing and installing the pore pressure meter in foundation or embankment will be made at the unit prices per number stated in the Bill of Quantities, which the unit prices shall include the cost of all labor, tools, equipment and materials including connecting, testing, protecting and maintaining the meter; and drilling holes for installing the foundation-type meter, excavating, backfilling and other costs and expenditures necessary to complete the work.

(2) Earth pressure meter

Measurement for payment for furnishing and installing the earth pressure meter will be made on the basis of the actual number of the earth pressure meter installed according to the Drawings and Specifications and as approved by the PMO/Engineer.

Separate measurement and payment for furnishing and installing the joint box and cable for the earth pressure meters will be made as stated in sub-clause T10.8.5.

Payment for furnishing and installing the earth pressure meter will be made at the unit price per number stated in the Bill of Quantities, which the unit price shall include the cost of all labor, tools, equipment and materials including connecting testing, protecting and maintaining the meter; excavating, backfilling and other costs and expenditures necessary to complete the work.

(3) Multi-layer settlement meter

Measurement for payment for furnishing and installing the multi-layer settlement meter will be made on the basis of the actual set of the crossarm type settlement meter installed at the 2 locations, at Sta. No. 10 and Sta. No. 16, respectively, according to the Drawings and the Specifications and as approved by the PMO/Engineer.

Payment for furnishing and installing the multi-layer settlement meter will be made at the unit price per set stated in the Bill of Quantities, which the unit price shall include the cost of all labor, tools, equipment and materials necessary for installation of the measuring pipes and crossarm; drilling holes for the foundation, providing and removing the protective fill, excavating, embanking, backfilling with selected sand and cement mortar, protection with concrete block at the top and other auxiliaries and expenditures necessary to complete the work.

T10.8.2 Surface displacement survey points and reference points for sediment monitoring

Measurement for payment for construction of the surface displacement survey points and reference points for sediment monitoring will be made on the basis of the actual number of the said points installed according to the Drawings and the Specifications and as approved by the PMO/Engineer.

Payment for installation of the surface displacement survey points and reference points for sediment monitoring will be made at the unit prices per number stated in the Bill of Quantities, which the unit prices shall include the cost of all labor, tools, equipment and materials including excavating, concreting, backfilling, surveying, maintaining, furnishing levelling device and other costs and expenditures necessary to complete the work.

T10.8.3 Leakage measuring facility

Measurement for payment for furnishing and installing the leakage measuring facility will be made on lump sum price stated in the Bill of Quantities, which price shall include the cost of all labour, tools, equipment and materials required for installation of the leakage measuring chamber with inlet block, screen, triangular weir, wing walls and other necessary auxiliaries according to the Drawings and the Specifications and as approved by the PMO/Engineer.

Payment for furnishing and installing the leakage measuring facility at the entrance of the inspection tunnel will be made in each unit price stated in the Bill of Quantities, which price shall include the cost of all labor, tools, equipment and materials necessary for furnishing, installing and testing only the measuring weirs, and other costs and expenditures necessary to complete it.

T10.8.4 Water level detector and indicator

Measurement and payment for furnishing and installing the water level detector and indicator with water level gauge staff will be made on lump sum price stated in the Bill of Quantities, which price shall include the cost of all labour, tools, equipment and materials required for installation of the water level detector and indicator with water level gauge staff and other necessary auxiliaries according to the Drawings and the Specifications and as approved by the PMO/Engineer.

T10.8.5 Relay terminal box, converter and cable

Measurement for payment for furnishing and installing relay terminal box, converter and cable will be made on the basis of the actual number of relay terminal box, converter installed and actual length of cables, according to the Drawings and the Specifications and as approved by the PMO/Engineer.

Payment for furnishing and installing the relay terminal box and converter, and cable will be meter be made at the unit price per number and per meter respectively stated in the Bill of Quantities, which unit prices shall include the cost of all labour, tools, equipment and materials necessary for installation of boxes and cables, excavation for trenches, providing and removing the protective fill, backfilling with selected sand and items necessary to install the boxes, converter and cables.

T10.9 Recording and Data Processing System

T10.9.1 General

The recording and data processing system consists of data aquisition controller and personal computer including such exclusive auxiliaries and periphery as scanner, printer, plotter, A.C. stabilizer, etc.

Data measured at each location will be transmitted to the personal computer for display and processing by the following manner.

- Pore pressure (on-line)
- Earth pressure (on-line)
- Leakage water (on-line)
- Reservoir water level (on-line)
- Multi-layer settlement (off-line)
- Slope displacement (off-line)

The system will be housed in the dam control house

T10.9.2 Requirement

Devices of the system shall conform to the following or equivalent approved by the PMO/Engineer.

1) Data acquisition controller(scanner)

- Connecting point	: 24 (max.)
- Channel display	: radiation diodo
- Power source	: A.C. 200 V, 50/60 Hz

2) Personal computer

- Hard disk capacity	: 200 MB
- CPU	: 32 bit
- Memory	: 4 MB

3) Printer

- Type	: Laser printer (post script)
- Printing speed	: 8 page/min. (max.)

4) Plotter

- Type	: Wire dot-matrix type
- Resolution	: 720 dpi
- Command	: HP-GL
- Paper size	: A3 size (max.)

5) A.C. stabilizer

- Input voltage	: 220 V
- Fluctuation range of input voltage	: ± 10 - 30 %
- Output voltage	: 100 V ± 10 %
- Capacity	: 250 - 500 VA
- Frequency	: 50/60 Hz
- Response velocity of input fluctuation	: 0.04 S
- Current strain	: 5 %

T10.9.3 Measurement and payment

Measurement and payment for supply and installation of the system will be made on lump sum price for the data acquisition controller and data processing system with periphevy stated in the Bill of Quantities, which price shall include the cost of all labor, tools, equipment and materials required for installation of the system and other necessary auxiliaries according to the Drawings and Specification and as approved by the PMO/Engineer.

Payment will be made on the number measured as above at the lump sum prices stated in the Bill of Quantities, which prices shall constitute full compensation for the cost of all labours, tools, apparatus, equipment and materials including these for tests, consumables and other items necessary to complete the system.

CHAPTER T11 SPILLWAY STEEL BRIDGE

T11.1 Scope of Works

These Specifications cover general items in connection with the fabrication, transportation and painting of steel bridge (composite girder bridge). The Contractor shall carry out all of the above works referring to the Drawings attached herein and in strict accordance with the Specifications, and as directed by the PMO/Engineer. The steel bridge structure specified herein shall be welded structure and all field connection shall be done with high tensile strength bolt.

T11.2 Applicable Standard

All the works shall be made in accordance with the following standards or equivalent standards approved by the PMO/Engineer.

The Contractor shall submit to the PMO/Engineer for his approval a list of name of Standards to be applied.

(1)	Japan Road Association	:	Specification for Highway Bridge
(2)	Japan Road Association	:	Manual for Steel Highway Bridge Construction
(3)	Japan Road Association	:	Standard Specifications for Steel Highway Bridge, Design and Fabrication
(4)	Japan Road Association	:	Standard Specifications for Welded Steel Highway Bridge
(5)	Japan Road Association	:	Manual for Steel Highway Bridge Painting
(6)	Japan Standard Association	:	Japan Industrial Standard (JIS)
(7)	ASTM	:	American Society for Testing and Materials
(8)	AASHTO	:	American Association of State Highway and Transportation Officials
(9)	BS	:	British Standards Institution

T11.3 Materials

T11.3.1 General

Steel materials to be used shall conform to the following requirements. The Contractor shall submit the list of materials to be used to the PMO/Engineer for his approval together with the Drawings and

Specifications. The Contractor shall make the material testing and shall submit to the PMO/Engineer for his approval of the test results.

T11.3.2 Steel for general use

Steel plate, flat bar, angle and channel for steel structure shall conform to the following standards or equivalent.

JIS G 3101	Structural steel for general structure (SS41, SS50)
JIS G 3106	Rolled steel for welded structure (SM41, SM50, SM50Y, SM53)

T11.3.3 Bolt and nut

High tensile strength bolt and nut to be used for all field connections shall be in accordance with JIS B 1186 (High Strengthen Hexagon Bolt, Hexagon Nut and Plain Washers for Friction Grip Joints) or equivalent.

T11.3.4 Stud

Shear connector studs shall conform to the requirements of JIS G 3101 (Structural Rolled Steel for General Use), or equivalent. Finished studs shall conform to the requirements of stud welding test of Japan Road Association, "Specifications for Highway Bridges."

T11.3.5 Welding rods

Welding rods shall conform to the following standards, or equivalent.

JIS Z 3211	Covered electrodes for mild steel.
JIS Z 3212	Covered electrodes for High Tensile Strength Steel.

T11.3.6 Storing of material

Structural steel, whether raw or worked, shall be stored on pillows or blocks above the ground in bridge manufacture yard. Care shall be exercised to protect steel material from dust, oil and other detrimental matter and to provide anticorrosive measures.

T11.4 Fabrication

The Contractor shall carry out the fabrication of steel materials in accordance with the detailed design, specifications and method approved by the PMO/Engineer. The Contractor shall exercise his care to the fabrication of the following matters.

1) Full size drawings

Imperfection in design drawings and anticipated trouble on fabrication shall preferably be checked with full size drawings which have necessary accuracy before starting of fabrication.

2) Plan of cutting plate

Cutting of plate for main members shall be planned so as to make the direction of main stress coincide with the roll direction.

3) Scratching

In case of scratching, scar by chisel or punch shall not be given on such portion that is left intact after completion as ever.

4) Cutting

Cutting of main members shall be done by automatic gas cutting. The quality of gas cut surface and gas finished groove surface shall be directed by the PMO/Engineer.

Fillers, Tie-plates, shape steels, gusset plates and stiffeners with thickness not greater than 10 mm, may be cut by shear, but if there are remarkable form edges, burrs on the surface and ragged edges along the cut line, the edge line shall be so smoothly finished by edge shaving or grinder finishing that these defects are completely removed.

5) Shaving

The surface roughness of shaved surface of steel members shall not be greater than 50S.

6) Opening holes

Opening holes shall be done with drill or combination of drill and reamer up to the specified diameter. In case of opening holes up to the specified diameter before shop assembling templets shall be used. For the opening holes in plate of subsidiary members with thickness not greater than 12 mm, punching up to the specified diameter may be done. Burrs on the edge around the hole produced by punching shall be shaved off.

7) Cold forming

In case of bending of plates without heating, the inner diameter of the steel plate shall be not less than 15 times of the thickness.

T11.5 Welding

Unless otherwise provided herein or directed by the PMO/Engineer, the work relating to welding shall be performed in accordance with the sub-clause 9.3.2.

In the butt joints of main members, radiographic tests shall be made in accordance with JIS Z 3104 Method of Radiographic Test and Classification of Radiographs for Steel Welds or equivalent, and the test results shall fullfill the following requirements.

Tension member	:	equal to or better than Class 2 specified in JIS Z 3104
Compression member	:	equal to or better than Class 3 specified in JIS Z 3104

T11.6 Shop Assembling

T11.6.1 General

In the shop assembling, there shall be provided appropriate supportings so that each member is free from any stress. In the shop assembling, field splices and connections of main parts shall be tightly fastened by the use of drift pins and bolts not less than 30% of total number of bolt holes.

T11.6.2 Accuracy of shop assembling

Accuracy of shop assembling shall be as directed by the PMO/Engineer.

T11.7 Painting

T11.7.1 Condition for painting

Painting shall not be applied when it is very moist, when it is forecast to rain before the coat of paint gets dry, when the surface of steel is wet, or when the temperature of steel is high in hot sunshine and the coat of painting is in danger of forming bubbles.

T11.7.2 Rust removing and cleaning

Surfaces of steel shall be thoroughly cleaned, removing rust, black scale, dust, oil and grease and other attached substances in advance of painting work.

When the steel members and bridge girders after completion of rust removal are in danger of rusting before painting, a proper coating as primer paint shall be applied.

T11.7.3 Painting

1) The number of coverages of paint shall be as follows

Shop painting anticorrosive	paint	:	2 coverages
Field painting second	paint	:	1 coverage
final	paint	:	1 coverage

2) Pores or holes of steel where water is anticipated to penetrate shall be backfilled by either paste paint, oil putty, or unsaturated polyester prior to field painting.

3) All markings on the steel shall be completely removed prior to field painting.

4) The color of paint for first application after firle painting with anticorrosive paint shall be sufficiently different from that of final paint so that it will not stain the color of final paint. The color of these final paints will be directed by the PMO/Engineer.

T11.7.4 Memorial record for painting

After completion of painting, the Contractor shall prepare and establish a memorial record for painting in a manner and at locations in accordance with the direction by the PMO/Engineer.

T11.8 Packing and Transportation

Each member shall be marked with an erection mark before transportation. Erection mark shall generally be painted. Weight and center of gravity of the member weighting more than 5 tons shall be marked by painting on the visible portion. If damage is likely to occur during transportation, packing shall carefully be done before start of transportation. Transportation schedule shall be prepared and submitted for an approval of the PMO/Engineer in advance.

T11.9 Erection of Steel Structure

T11.9.1 General

(1) Checking steel tape

Steel tapes to be used for measurement in erection of structure shall be checked to the standard steel tape which shall conform to the requirement of JIS B 1512 or equivalent in the presence of the PMO/Engineer for his approval.

(2) Handling and storing steel members in field

Steel members shall be stored on blocks or boxes well above ground, and maintained in clean and well drained condition. Beams or girders shall be stored in the positions which they will finally occupy in the structure. Posts, columns, suspension, diagonal bracing, chords, and other long members shall be stored with intermediate supports in order to prevent strain due to deflection.

If the members are to be stored for a long time, proper measures such as shed or cover sheet shall be provided to prevent damage by rust or corrosion.

(3) Preparation work

The necessary yard to store, assemble and erect steel structures shall be constructed upon an approval of the PMO/Engineer before commencing it.

T11.9.2 Erection

(1) Method of erection

The Contractor shall consult with and obtain the approval of the PMO/Engineer for the detailed method and time of erection, and stagings, and for tools and equipment to be used. The stagings shall be proper design and capable of safe bearing against any load which is anticipated on them. On an as-needed basis, the Contractor shall submit calculation data for estimated loads on the stagings to the PMO/Engineer for approval.

The approval of the PMO/Engineer shall not be considered to relieve the Contractor's responsibility for the safe fulfillment of the work in strict accordance with the Drawings and the Specifications, even though his method and equipment was approved.

(2) Assembling members

The members shall be accurately assembled as shown on the Drawings with the match-marks fitted. Members shall be carefully handled so that no member will be bent, broken, or otherwise damaged. Shock which will injure or distort the member shall not be given.

Bearing surface and contact area shall be thoroughly cleaned prior to member assembling. Members which are extremely distorted shall be rejected. If the distortion is slight, the members shall be corrected as approved by the PMO/Engineer.

When the girder is erected on stagings, suitable blocks shall be inserted between the girder and the stagings so as to provide the specified fabrication camber and erection camber.

(3) Temporary fitting-up bolt

After the member have been assembled, they shall be inspected by the PMO/Engineer prior to bolting. Splices and in-place connections shall be tightened by fitting-up bolt or drift pin prior to bolting. The member of bolts or pins shall be approximately half the number of bolt. No gap shall be allowed between the surface of members to be connected. The nominal diameter of fitting-up bolts or pins shall be equal to that of bolt. When exchanging fitting-up bolt or drift pin to high tensile strength, a large number of bolt or pin shall not be pulled out at the same time.

(4) Misfits of bolt holes

Misfitted bolt holes shall be corrected after the approval of the PMO/Engineer. Slight correction by means of reamer, cutter or chipper may be permitted. Reaming shall be made vertical to the member surface. The Contractor shall be responsible for all misfits, errors, deformation or damages, and shall make necessary correction or replacement at his expense.

(5) High tensile strength bolt connection

Surfaces of members to be in permanent contact shall be free from black scale, and shall have coarse surface. The surfaces shall not be painted.

When members are bolted in field, rust on the surface shall be removed by wire brushing, and shall be cleaned adequately and free from oil or dirt.

Members shall be brought into contact enough with splice plates or gusset plates by tightening bolts.

Splices of members whose thicknesses are different on their surfaces to be contact shall conform to the following requirements.

Defference of thickness	Treatment
not greater than 1 mm	not required
less than 3 mm	There shall be taper to eliminate the difference.
not less than 3 mm	Fillers shall be used.

(6) Tightening of bolts

The wrenches for bolting shall be calibrated at proper intervals, and their accuracy shall be checked.

Bolt tension shall generally be induced by turning nuts. If heads of bolts are turned, change of torque coefficients shall be confirmed.

If bolts are tightened by calibrated wrench method, tightening torque shall be determined so that standard bolt tension is induced uniformly.

If bolts are tightened by turn-of-nut method, nut rotation as directed by the PMO/Engineer shall be added to the position where bolts are tightened by torque wrench until the parts of the joint are bought into full contact with each other, or where bolts are tightened by spud wrench with the full effort of a man. But turn-of-nut method may be used only for the bolts designated as F8T and B8T.

(7) Bolts tension for tightening

Bolts for friction type connection shall be tightened so that designed bolt tension will be secured as directed by the PMO/Engineer.

Bolt tension for tightening shall generally be 10% greater than designed bolt tension.

(8) Sequence of tightening

Tightening bolts shall be progressed from the center of the joint to its edges, and retightening shall generally be done.

(9) Packing and storing of bolt sets

Transportation, packing and storing of bolt sets shall be done carefully in order that the same condition of bolt sets as in shop is kept until tightening on site.

(10) Inspection of tightening

Marking shall be done at tightening so that completion of tightening as assured.

For calibrated wrench method, inspection by torque wrench shall be done immediately after tightening. In this case the amount of bolts for inspection shall generally be 10% of bolts for each group of bolts.

For turn-of-nut method, inspection for appearance by marking shall be done.

(11) Procedure of tightening in combined use of welding and friction type high tensile strength bolts

In case of combined use of welding and friction type high strength bolts, high strength bolts shall generally be tightened after welding is completed. When welding is done after tightening high strength bolts, the effect by restriction shall be considered.

T11.9.3 Field welding

Field welding shall be done carefully in accordance with the method designated in the design.

Enough attention shall be paid to clean and dry condition of welding materials, and the necessary facilities to keep them in good condition shall be provided in the field. Condition of groove and restriction to plates shall be checked before field welding.

Notes for welding and inspection shall generally conform to those in shop welding.

T11.9.4 Setting of bearings

Bearings shall be set accurately at the required position. Setting of bearings and anchor bolts to substructures shall be done elaborately.

Setting position of bearing shall be determined by compensating temperature difference considering the atmospheric temperature at the setting so that the relative position between the bearing and the superstructure will correspond to the standard position at the standard temperature considered in the design.

After setting of bearings it shall be confirmed that bearings have required functions for displacement and rotation.

T11.9.5 Field painting

Two layers of finishing paint shall be coated on surface of steel member after finish of field erection at the site. The paint shall be of oil paint. The color, quality and coating method thereof shall be subject to an approval of the PMO/Engineer before use.

T11.9.6 Removal of falsework or staging

Upon completion of erection, the Contractor shall remove all falsework or staging, excavated or useless material, rubbish and temporary facilities according to the indication of the PMO/Engineer. All excavated material or staging placed in the stream during construction shall be removed.

T11.10 Incidental Facilities

T11.10.1 Bearing shoe

Material for bearing shoes shall conform to JIS G 3101 (Structural Rolled Steel for General Use), JIS G 5101 (Cast Steel, SC46). JIS G 5501 (Cast Iron, FC15) and Friction Plate or equivalents.

T11.10.2 Expansion joint

Steel material for expansion joint shall conform to JIS G 3101 (Structural Steel for Welded Structure) and JIS G 3106 (Rolled Steel for Welded Structure) or equivalents.

T11.10.3 Drainage facilities

Material for drainage facilities shall conform to JIS G 5501 (Cast Iron, FC15), JIS G 3452 (Gas Pipe) and JIS K 6741 (Vinyl Pipe) or equivalent. All drainage facilities shall be galvanized unless otherwise specified.

T11.11 Construction

T11.11.1 Bearing shoes

Bearing shoes of steel bridges shall be accurately set in the specified position before assembling superstructure members. This setting work shall be carefully done with cement mortar so that the bottom of bearing shoes will adhere tightly to the top of abutment. When bearing shoes are set after assembling superstructure members at the approval of the PMO/Engineer, cement mortar shall be thoroughly spread under the bottom of bearing shoes, and they shall be completely adhered to the top of substructure. Anchor bolts for bearing shoes shall be constructed in accordance with the requirements of "Placing of Anchor Bolt."

T11.11.2 Expansion joint

Surface of metal devices for expansion joint shall be finished to a smooth plane to fit the bridge surface. Special care shall be exercised to prevent movement of metal devices for expansion joint during placing concrete. Width of expansion joints shall be so determined that it will conform to the width shown on the Drawings at air temperature of 25.0°C.

T11.11.3 Drainage facilities

Catch-basin and drainage pipe shall be installed in accordance with the Drawings or as directed by the PMO/Engineer.

Catch-basin and drainage pipe shall be held firmly so that it will not be displaced during placing of concrete and bituminous surfacing.

T11.11.4 Measurement and payment

The measurement of quantities of fabrication, transportation, erection and construction of girder steel material consisting of main girder, cross beam, end sway, internal sway, lateral bracing, etc., painting and incidental facilities and payment thereof shall be made at the contract unit prices as follows.

Item	Unit
1) Steel girder	kilogram
2) Painting	square meter
3) Bearing shoe	each
4) Expansion joint	kilogram
5) Drain hole including pipe and catch-basin	each
6) Joint filler	square meter

The prices and payments shall be full compensation for furnishing all materials, labour, equipment, technical reward necessary to complete all the works specified in this Specifications.

T11.12 Concrete Work for Slab

T11.12.1 General

Unless otherwise provided herein or directed by the PMO/Engineer, the work relating to the concrete work for slab, parapet wall and its base for guard rail and asphalt surfacing shall be performed in accordance with CHAPTERs T4 and T5, respectively.

T11.12.2 Classification of concrete and concrete mix proportion

Classification of concrete to be used for concrete slab shall be as follows and as shown on the Drawings.

Class C Parapet wall and its base for guard rail

Class G Reinforced concrete for slab of composite girder bridge.

Determination of concrete proportion

The Engineer will design concrete mixes on the basis of the following design standard.

Class of concrete	Compressive strength at 28 - day (kg/cm^2)	Slump (cm)	Max. size of aggregate (mm)	Air content of fresh concrete (%)
Class - C	180	13 ± 1	40	3 - 5
Class - G	270	9 ± 1	20	4 - 6

The PMO/Engineer will determine the concrete mix proportions based on the above design standard and aggregates selected by the Contractor to be used in the work.

T11.12.3 Measurement and payment

The measurement of quantities of concrete work for slab, parapet wall and its base for guard rail and asphalt surfacing and payment thereof will be made by the same procedure as those in CHAPTER IV CONCRETE WORK and CHAPTER V ROAD WORK, to which price and payment shall be full compensation for furnishing all materials, labour, equipment, technical reward necessary to complete all the work specified in this Specification..

APPENDIX TO TECHNICAL SPECIFICATIONS

DIVERSION CLOSING GATE AND TOP BEAMS

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APPENDIX A DIVERSION CLOSING GATE AND TOP BEAMS

A.1 General

A.1.1 Drawings and Documents to be Supplied by the Contractor

(1) Drawings and Documents for Approval

Prior to commencement of manufacturing of the diversion closing gate, the Contractor shall submit the design criteria, calculations, specifications, dimensioned and traced drawings and diagrams showing all details of the gate and materials to be used as well as all arrangements related to the works, for approval of the PMO/Engineer and the Employer simultaneously. These drawings and data with stamp of "FOR APPROVAL", "DATE OF SUBMISSION" and "CONTRACTOR'S SEAL" shall be prepared in the English language. The Contractor shall allow a period of at least six (6) weeks for such approval procedure and another one (1) week for return mail after receipt by the PMO/Engineer. One of the sets submitted will be returned to the Contractor by the PMO/Engineer with a remark, which can be either "APPROVED" or "APPROVED EXCEPT AS NOTED" (authorizing the Contractor to proceed with the contractual works taking account of the Notes) or "RETURNED FOR CORRECTION AND RESUBMISSION". In any case, the sets shall be submitted allowing sufficient time to permit modifications to be made, if such are deemed to be necessary and/or are instructed by the PMO/Engineer without delaying the completion of the Works. Claims or extensions of time will not be permitted on account of the late submission of drawings and documents to the PMO/Engineer or for delays caused by drawings and documents being not approved by the PMO/Engineer.

It is to be understood, however, that approval of drawings and documents will not relieve the Contractor of any responsibility in connection with the Work.

All drawings and documents to be submitted for approval or sent to the Employer or the PMO/Engineer for any other reason shall be sent by registered airmail or by hand.

The title of the drawings, the signature of the Contractor's responsible engineer, the date prepared, the drawing number, etc. shall appear in the bottom right-hand corner of the drawing. The size of drawings shall be as follows:

A1	594 mm x 841 mm
A2	420 mm x 594 mm
A3	297 mm x 420 mm
A4	210 mm x 297 mm

A box 200 mm wide by 100 mm high shall be kept unoccupied above the title block of drawing for the PMO/Engineer's comments.

(2) For-Work-Drawings

After approval of the drawings and documents by the PMO/Engineer, the Contractor shall supply copies of the approved-drawings with stamp of "FOR-WORK-DRAWING", "DATE OF APPROVAL" and "CONTRACTOR'S SEAL" to the Employer and the PMO/Engineer.

(3) Final Drawings and Documents

After all items of the Work have been manufactured, erected and commissioned, a complete set of the negatives of the drawings previously approved and/or corrected during site works are to be submitted to the Employer and the PMO/Engineer.

Negatives of the drawings to be submitted to the Employer shall be of "Mylar film" or other approved permanent transparent materials and one set of microfiche, and those to the PMO/Engineer shall be of microfiche.

The reduced size of drawings into A3 size shall be bound in A4 size covers and be submitted to the Employer and the PMO/Engineer.

(4) Required Numbers of Drawings and Documents

Numbers of the drawings and data to be submitted to the Employer and the PMO/Engineer shall be as follows:

	To the Employer	To the PMO/Engineer
Drawings and data for approval	1 copy	4 copies
For-work-drawings and data	1 copy	4 copies
Within two (2) months upon Completion of the Work		
Complete set of negatives of drawings and data	1 set	NIL
Complete set of microfiche of drawings and data	NIL	1 set
Complete set of bound print of drawings and data		
Full size	4 sets	NIL
Reduced size (A3 size)	4 sets	1 set

Further copies of particular drawings and data are to be provided at the Contractor's own expense if so requested by the PMO/Engineer or the Employer.

A.1.2 Test Procedure Instructions

The Contractor shall submit to the PMO/Engineer for approval, during or immediately following the submission of drawings, the instructional test procedures, describing each test to be performed at the Contractor's shop and at the Site. The test procedures shall define the sequence of the tests, the equipment preparation and operation procedures to be followed and the detailed procedures for conducting the tests, tolerances for dimension and/or quality controls and other necessary items for the tests. The test procedures shall be separately prepared for the tests to be performed at the shop and at the Site. These procedures shall be submitted and distributed in the same manner as the drawings.

A.1.3 Working Stress and Design

The design, dimensions and materials of all parts shall be such that they will not suffer damage under the most adverse conditions nor result in deflections and vibrations which might adversely affect the operation of the equipment. Mechanism shall be so constructed to avoid sticking due to rust or corrosion.

All parts which will have to be dismantled or which might have to be dismantled, for purposes of servicing or replacement shall be retained with anti-corrosive fasteners. The type, material and size of all fasteners shall be selected to safely withstand the maximum superimposed direct, alternating,

kinetic and thermal loads and all loads induced by workmen when installing or removing the fasteners during the life of the equipment.

All design shall be such that the installation, replacement and general maintenance may be undertaken with the minimum of time and expense. The tolerances used for dimensions and finishes shall be selected with due consideration to the particular properties and functions of the parts and the corresponding accuracy required to obtain proper operation and tight sealing.

Wherever possible, all similar parts, including spare parts, shall be made to gauge and interchangeable. Such parts shall be of the same materials and workmanship and shall be constructed to such tolerances as to enable substitution or replacement from spare parts to be made easily and quickly.

Suitable structural steel bases or frames shall be provided where necessary to transmit to the concrete foundations all loads imposed by the various parts of the equipment. Such bases or frames shall be supplied complete with suitable anchor bolts and shall be so proportioned that the bearing loads imposed on the concrete foundations will not exceed the allowable stress given in A.2.2. (3).

All equipment supplied under this chapter shall be designed to minimize the risk of fire and consequential damage, to prevent ingress of vermin, dust and dirt, and accidental contact with electrically live parts or moving parts. The equipment shall be capable of continuous operation with minimum attention and maintenance in the exceptionally severe conditions likely to be encountered in a tropical climate.

Complete information regarding the design assumptions, loading and operating conditions, deflections and unit stresses used in the design shall be provided with the appropriate drawings by the Contractor to the PMO/Engineer.

The Contractor shall be deemed to have examined the Specifications and Drawings for Tender herewith and to have concurred with the design and layout of the Works, as being sufficient to ensure reliability and safety in operation, free from undue stresses, adequate drainage and other essentials for a satisfactory working of the gate.

It should be noted that the Drawings for Tender show only the general type of equipment and the principal dimensions and are not intended to define the exact details of the equipment to be furnished. Alternative details and arrangement will be considered. The said alternatives shall be listed up in the tender proposal, referring to clause IT.16 of the Instructions to Tenderers. As the Drawings indicate the outline of the structure in which the equipment is to be installed, special

attention shall be paid to the arrangements of the equipment so as to make optimum use of the available space. Any recesses required in this structure for alignment and grouting of embedded parts shall be determined by the Contractor.

A.1.4 Standards and Workmanship

(1) General

All materials shall be new, the best of their respective kinds and such as are usual and suitable for work of like character. All materials shall comply with the latest standards of the International Organization for Standardization (ISO) or Japanese Industrial Standards (JIS) unless otherwise specified or other equivalent standards, approved by the PMO/Engineer.

All workmanship shall be of the highest class throughout to ensure smooth and vibration free operation under all possible operating conditions, and the design, dimensions and materials of all parts shall be such that the stresses to which they may be subjected shall not render them liable to distortion, undue wear, or damage under the most severe conditions encountered in service.

All parts shall conform to the dimensions shown on and shall be fabricated and erected in accordance with approved drawings. All joints, datum surfaces, and matching components shall be machined and all castings shall be spot faced for nuts. All machined finish shall be shown on the approved drawings. All screws, bolts, studs and nuts and threads for pipes shall conform to the latest standards of the ISO covering these components and shall conform to the standards for metric size. The Contractor shall use exclusively the standards and size system presented in his tender and accepted and incorporated in the Contract.

The Contractor shall consider limitations of facilities available in Mauritius, and also the site conditions, while selecting the mechanical and electric equipment.

(2) Standard Specifications

The Japanese Industrial Standards issued by the Japanese Standards Association of Japan have been used throughout these Specifications. Other national or international standards may be accepted provided that the requirements therein are, in the opinion of the PMO/Engineer, equivalent to or better than the current issue of the Japanese Industrial Standards.

Unless otherwise specified, design and fabrication of the equipment shall conform to the applicable provisions of "Technical Standards for Water Gates and Penstocks" as issued by the Hydraulic Gate and Penstock Association of Japan.

If the Contract Documents conflict in any way with any or all of the above standards, the Contract Documents shall have precedence and shall govern.

All electrical equipment, material and details of installation shall comply with the requirements and the latest revisions of the following Standards and codes where applicable:

(a) International Organization for Standardization (ISO)
(b) International Electrotechnical Commission (IEC),,
(c) Japanese Industrial Standards (JIS),
(d) Standards of local regulatory bodies having jurisdiction over installation.

(3) Material Inspection and Testing

Material inspection and testing shall be as specified in A.1.6 (2).

(4) Shop Assembly

The shop assembly shall be as specified in A.1.6 (3).

(5) Castings

All castings shall be dense, sound and true to pattern, of workmanlike finish and of uniform quality and condition, free from blowholes, porosity, hard spots, shrinkage defects, cracks or other injurious defects, and shall be satisfactorily cleaned for their intended purpose. All castings shall be checked for defects before final machining.

Casting shall not be repaired, plugged, or welded without permission of the PMO/Engineer. Such permission will be given only when the defects are small and do not adversely affect the strength, use or machinability of the castings. Excessive segregation of impurities or alloys at critical points in a casting will be cause for its rejection. The largest fillets compatible with the design shall be incorporated wherever a change in section occurs.

Surfaces which do not undergo machining and are exposed in the final installation shall be dressed to provide a satisfactory appearance so that they will not require surface smoothing at site prior to painting.

(6) Forgings

The ingots from which the forgings are made shall be cast in metal moulds, the workmanship shall be first-class in every respect and the forgings shall be free from all defects affecting their strength and durability, including seams, pipes, flaws, cracks, scales, fins, porosity, hard spots, excessive nonmetallic inclusions and segregations.

The largest fillets compatible with the design shall be incorporated wherever a change in section occurs. All finished surfaces of forgings shall be smooth and free from tool marks.

The forging shall be clearly stamped with the heat number in such location as to be readily observed when the forging is assembled in a completed unit.

(7) Steel Plates, Bars, Pipes, etc.

Steel plates, bars, pipes, etc. used in the equipment shall be of steel conforming to or superior to the specified standards.

(8) Floor Plate

Checkered type floor plate shall be of an approved raised pattern. All edges of plate shall be planned and joints shall be cut so as to maintain continuity of pattern.

(9) Walkways, Ladders and Handrails

Adequate walkway, ladders, and safety handrails and guards shall be provided on and around each unit, where necessary, to afford access to and protection from all moving and electrical parts. Such items shall be designed to facilitate easy removal to permit free access to various parts of the unit.

(10) Machine Work

(a) General

All tolerances, allowances and gauges for metal fits between plain cylindrical parts shall conform to the ISO or JIS or other approved equivalent standards for the class of fit as shown on otherwise required. Sufficient machining stock shall be allowed on locating pads to ensure true surfaces of solid material. Bearing surfaces shall be true and exact to secure full contact. Journal and sliding surfaces shall be polished

and all surfaces shall be finished with sufficient smoothness and accuracy to ensure proper operation when assembled. Parts entering any machine shall be carefully and accurately machined. All drilled holes for bolts shall be accurately located and drilled from templates.

(b) Finished Surfaces

Surface finished shall be indicated on the Contractor's drawings and shall be in accordance with the JIS or other approved equivalent. Compliance with specified surface will be determined by sense or feel and by visual inspection of the work compared to standard roughness specimens, in accordance with the provisions of the above stated standards.

(c) Unfinished Surfaces

So far as is practicable, all works shall be arranged to obtain proper machining of adjoining unfinished surfaces. When there is a large discrepancy between adjoining unfinished surfaces, they shall be chipped and ground smooth, or machined, to secure proper alignment. Unfinished surfaces shall be true to the lines and dimensions shown on the drawings and shall be chipped or ground free of all projections and rough spots. Depressions or holes not affecting the strength or usefulness of the parts may be filled in an approved manner.

(d) Pins and Pin Holes

Pin holes shall be bored to gauge, smooth and straight, and at right angles to the axis of the member. The boring shall be done after the member is securely fastened in position. Pins shall be of hardened and ground steel and positively held in position. Wheels or rollers for use in gates shall be mounted on removable pins and have self-lubricating bushings or self-aligning roller bearings and brass washers.

(e) Lubrication

The lubrication shall be as specified in Clause A.2.10.

(f) Balancing

All revolving parts shall be truly balanced both statically and dynamically so that when running at normal speeds and at any load up to the maximum, there shall be

no excessive vibration due to lack of such balance and the gate shall operate with the least possible amount of noise.

(11) Welding

All welding shall be done either manually by the shielded metallic arc process or automatically by the shielded arc or submerged arc method.

The Contractor shall develop and submit a welding procedure for the approval of the PMO/Engineer. After the welding procedure has been approved, the Contractor shall record it on a special drawing which shall thereupon become one of the drawings of the Contract. Weld sizes and types shall be shown on all Contractor's drawings where welding is required.

Non-destructive examination such as radiographic or ultrasonic, or magnaflux or dye-penetrated inspection shall be carried out by the Contractor when required by the standards, the Specifications or the design criteria employed. All important welds which, in the opinion of the PMO/Engineer, may be subject to the full stress induced in the adjacent plate, or which, in the opinion of the PMO/Engineer or the Inspector, do not appear to conform to the welding standards, shall be non-destructively tested when required by the PMO/Engineer.

Suitable meters shall be provided to show the welding current and the arc voltage at all times during the welding operations. Unless otherwise specifically stated, welded parts requiring machine finish shall be completely welded before being finished.

Plates to be joined by welding shall be accurately cut to size and rolled by pressure to the proper curvature which shall be continuous from the edge. Flattening in the curvature along the edges with correction by blows will not be allowed. The dimensions and shape of the edges to be joined shall be such as to allow thorough fusion and complete penetration and the edges of plates shall be properly formed to accommodate the various welding conditions. The surfaces of the plates for a distance of 25 mm from the edge to be welded shall be thoroughly cleaned of all rust, grease and scale, to bright metal.

(a) Standard for Welding Procedure

The technique of welding employed, the appearance and quality of the welds made and the methods used in correcting defective work, shall conform to the American Welding Society (AWS) Standard D.1.1, or other approved equivalent standard.

(b) Qualification of Welders and Welding Operators

All welders and welding operators assigned to the Work shall have passed a qualification test, within the preceding six (6) months, for welders and welding operators, in accordance with JIS Z 3801 and/or Z 3841 or AWS D.1.1 or other approved equivalent standard. The Contractor shall furnish the PMO/Engineer with certified copies of reports of the results of physical tests of specimens welded in the qualification tests. If, in the opinion of the PMO/Engineer, the work of any welder at any time appears questionable, he shall be required to pass the appropriate requalification test. All costs of qualification tests shall be borne by the Contractor.

(c) Welding Electrodes

The welding electrodes shall conform to ISO 2560 or JIS Z 3211 or Z 3212, low hydrogen type covering or other approved equivalent standards.

Stainless type weld metal, where used in the water passages for protection against pitting, shall be chromium nickel steel. The type, chemical composition and JIS number of welding rods for this purpose shall meet with the approval of the PMO/Engineer.

If the workmanship is not satisfactory to the PMO/Engineer, the welding shall be chipped out to sound metal, tested and repair welded, subject to approval of the PMO/Engineer. The welding work contained such defect shall be inspected and tested all along the line by the same method used first as instructed by the PMO/Engineer to his satisfaction.

A.1.5 Protection, Cleaning and Painting

(1) General

The painting of the gate shall include the preparation of the metal surfaces, paint application, protection and drying of the paint coatings, as well as the supplying of all tools, labours and materials necessary for the entire painting work.

The finish color of all the gates shall be approved by the PMO/Engineer under the confirmation of the Employer. The Contractor shall propose a color scheme for the equipment and shall submit painted samples or color chips. A color chip shall be included

with the approved color schedule for each type of finish. The color of all undercoats shall match the color of the finish coat.

Paint shall be a product of reputable manufacturer and be available in Mauritius where applicable. Paint shall be delivered in the manufacturer's sealed tins, stored under cover and used within the guaranteed term of validity and by the method recommended by the manufacturer. The Contractor shall select the type of paints which shall endure five (5) years after application.

The Contractor shall prepare and submit the painting specifications for approval of the PMO/Engineer in the manner as stipulated in clause A.1.1 "Drawings and Documents to be Supplied by the Contractor" of the Technical Specifications. The painting specifications shall cover paint schedule, manufacturer's statement of the physical and performance characteristics for paint materials to be selected, and manufacturer's recommended procedures for the surface preparation, application, handling instructions, equipment, ambient conditions, mixing instructions, safety and storage instructions, etc. The procedures shall also include any special requirements for field repairs to the damaged coating and for the coating of field joints.

All parts which will ultimately be buried in concrete shall be cleaned and protected, before leaving the manufacturer's shop, by a portland cement wash or other approved method. Before being installed they shall be thoroughly descaled and cleaned of all rust and adherent matter.

(2) Surface Preparation

All oil, paraffin, grease and dirt shall be removed from the surfaces to be painted, by wiping the surfaces with a clean cloth dipped in mineral solvent. Following solvent cleaning, all weld spatters, slag, burrs, loose rust and mill scale and other foreign substances shall be removed by shot or grit-blasting to "Sa 2 1/2" of Swedish Standard SIS 055900 or SSPC-SP10 of Steel Structures Painting Council Manual Volume 2. Special attention shall be given to cleaning of corners and converging angles. Blast cleaned surfaces showing plate surface defects such as scabs or sharp gouges shall be repaired in an approved manner prior to painting.

After blast cleaning, the surface shall be dusted off or blown off with compressed air free of detrimental oil and water. All surfaces to be painted shall be completely dry, clean and free from moisture just prior to and during painting. If rust forms or the surface becomes

contaminated in the interval between cleaning and painting, recleaning to the same degree shall be required.

(3) Application Procedure

The application of protective coating shall be carried out at the Contractor's shop and/or field shop, whenever possible. Painting work at erection site shall be limited to touch-up coatings for damaged areas and coatings for field welding portions.

All paint, when applied, shall provide a satisfactory film and a smooth even surface. Paint shall be thoroughly stirred, strained, and kept at the uniform consistency during application. Paint shall not be applied when the temperature of the metal or surrounding air is below 10 degrees C and that of the metal is above 50 degrees C, or when the humidity is above 90 percent, or when it threatens to rain before the painted coat gets dry. Each coat shall be protected during the initial curing period against the possibility of moisture condensation or contamination with foreign matter. Paint shall be applied by brushing and/or airless spraying.

When the coating material is applied by spraying, suitable means shall be provided to prevent segregation during the coating operation. Free oil and moisture shall be removed from the air supply lines of all spraying equipment. Each coat shall be uniform and free from runs, sags and other imperfections. The time between successive coats shall be not less than the minimum nor more than the maximum re-coating time specified by the paint manufacturer.

The paint shall be applied so that the thickness at any point is not less than that stipulated in the approved painting specifications. Surfaces not required to be coated, but adjacent to surfaces which are to be cleaned and coated, shall be adequately protected during cleaning and coating.

Repairs to damaged areas of the coating system shall be carried out strictly in accordance with the approved painting specification.

Because of the flammable and toxic nature of the coating materials, the Contractor shall take precautions to eliminate hazard that may arise during the application of the coating. Smoking and welding shall not be allowed within 10 m of the place when painting is in progress.

Where steelwork is to be welded, only the primer shall continue over the weld area. Subsequent coats shall be kept back 100 mm from the weld and completed after welding. The primer shall be such that no toxic fumes are given off during welding. Alternatively, approved temporary protection such as taping may be provided as an alternative to priming the weld areas. The edges of shop coats exposed on removal of the tape shall be treated in accordance with the manufacturer's instructions to ensure adhesion to coats applied at Site.

Painting shall be stopped off 75 mm from the edges of interface areas for high strength friction-grip bolts. Painting over and around such bolts shall be completed as specified after assembly.

(4) Surfaces not to be Painted

Bronze, brass, machined parts surfaces of gear teeth, finished ferrous surfaces, surfaces in rolling or sliding contact after field assembly and hoist ropes shall not be painted. All corrosion-resisting steel surfaces for bearings and machinery parts shall not be painted.

On completion of cleaning, the surfaces not to be painted shall be coated with an approved rust preventive coating material or an adhesive plastic film to protect the surfaces from minor mechanical damage and corrosion during shipment and storage at the Site. The coating material shall be stripped off after field erection of equipment.

Unassembled fittings, pins, bolts and nuts shall be oiled and wrapped with moisture-resistant paper or protected by other approved means.

(5) Paint Schedule

One epoxy resin zinc rich primer coat and two or three coats of coal-tar epoxy resin paint, total dry film thickness of 0.45-0.60 mm, shall be applied to the exposed surfaces of gate leaf, all guide frames, top beams, appurtenant parts and of embedded frames which are not made of the corrosion-resisting steel plates.

Commercial equipment other than those above specified may be painted in accordance with the manufacturer's standard practice, subject to approval of the PMO/Engineer.

(6) Inspection

All work shall be subject to inspection by the Contractor. The inspection shall be performed in accordance with the approved test procedure prescribed in clause A.1.2 "Test Procedure Instructions" of the Technical Specifications.

Following the visual inspection on surfaces that have been coated, the dry film thickness of coating shall be checked at as many places as possible to prove the thickness overall to be to the specified minimum thickness by the electromagnetic thickness meter. Further, for the purpose of measuring the continuity of coatings, coated areas shall be examined by the pin hole detector ("Holiday" detector). The peeling inspection shall also be performed for the coated areas.

A.1.6 Inspection and Testing during Manufacture

(1) General

The PMO/Engineer shall be entitled at all reasonable times during manufacture to inspect, examine and test the materials and workmanship and check the progress of manufacture of the gate to be supplied under the Contract. This shall take place on the Contractor's premises during working hours. If the gate is being manufactured on other premises, the Contractor shall obtain permission for the PMO/Engineer to carry out such inspection, examination and testing on those premises.

No such inspection, examination or testing shall release the Contractor from any obligation under the Contract.

The cost associated with all such tests and inspections shall be borne by the Contractor.

(2) Material Inspection and Testing

Materials, parts and assemblies thereof, entering into the Work shall be tested, unless otherwise directed, according to the best commercial method for the particular type and class of work. When the manufacturer desires to use stock material not manufactured specifically for the equipment furnished, satisfactory evidence that such material conforms to the requirements herein stated, shall be furnished, in which case tests on these materials may be waived. Certified mill test reports of plates and sections will be acceptable. In addition to the mechanical tests required by the Technical Specifications, all materials shall be examined in the shop for laminations and imperfections before incorporating them into the Work and any defective material shall be rejected.

Witness tests and inspection of material may be made at the place of manufacture by the inspector appointed by the PMO/Engineer, unless otherwise specified. Such witnessing and inspecting will be conducted so as to interfere as little as possible with manufacturing operation. The Contractor shall however comply with any reasonable request made by the inspector concerning the method of test or correction of defective workmanship.

All castings weighing 226.8 kg (500 pounds) or more shall have test pieces attached from which test specimens may be prepared. The number, size and location of the test coupons shall be to the approval of the PMO/Engineer. Faulty material or materials found to be inferior to that specified shall be rejected and removed at once, and shall not be used in any part of the Work.

Test pieces of other structural materials shall be provided as required by the PMO/Engineer.

The ultimate strength, limit of elasticity, ductility, hardness, etc., will be determined from such test pieces.

The Contractor shall furnish, free of charge, all test pieces, blankets, etc., cut and machined to the sizes, shapes and dimensions as directed by the PMO/Engineer. The testing of the specimens will be carried out by the Contractor at his own expense, and shall be performed as directed by the PMO/Engineer.

Test pieces which represents rejected material shall be preserved and become the property of the Employer. Copies of all test reports shall be mailed to the PMO/Engineer.

Waiving of inspection by the PMO/Engineer shall not relieve the Contractor of the responsibility for supplying material and workmanship acceptable to the PMO/Engineer.

(3) Shop Assembly and Test

The complete gate including seals, guide frames and top beams and other accessories shall be assembled and tested in the shop in the approximate position that they will have after installation in the diversion tunnel inlet. While assembled, each gate guide frames and top beams shall be checked for dimensions, tolerances, and accuracy of alignment. Any error and misalignment discovered shall be promptly corrected to the satisfaction of the PMO/Engineer. The seals shall be fitted to their supports during the shop assembly. Sealing plates, side roller paths and sill beams for the guide frames shall be checked by

means of straight edge and feeler gauges. Parts shall be clearly matchmarked before disassembling for shipment.

(4) Dates for Inspection and Testing

The Contractor shall give the PMO/Engineer reasonable notice in writing of the date and place at which the equipment will be ready for testing as provided in the Contract and unless the PMO/Engineer will attend at the place so named, within 10 days of the date which the Contractor stated in his notice the Contractor may proceed with the tests, and shall be deemed to have been made in the PMO/Engineer's presence, and shall forthwith forward to the PMO/Engineer duly certified copies of the test readings.

The Contractor shall agree with the PMO/Engineer the time and place for the testing of gate as provided in the Contract. The PMO/Engineer shall give the Contractor 72 hours notice of his intention to attend the tests.

If the PMO/Engineer does not attend on the date agreed, the Contractor may, unless the PMO/Engineer instructs the Contractor not to do so, proceed with the tests, which shall be deemed to have been made in the PMO/Engineer's presence.

The Contractor shall forthwith forward to the PMO/Engineer duly certified copies of the test results. If the PMO/Engineer has not attended the test, he shall accept the validity of the test readings.

(5) Facilities for Testing

Where the Contract provides for tests on the premises of the Contractor or of any Subcontractor, the Contractor shall provide such assistance, labour, materials, electricity, fuel, stores, apparatus and instruments as may be necessary to carry out such tests efficiently.

(6) Reports of Inspections and Tests

The Contractor shall provide the PMO/Engineer with ten (10) copies of all inspection and test reports per every shipment/delivery, together with the written application for issuance of the "Certificate of Inspection" as required in subclause "(5) Inspection and Testing During Manufacture - Certificate of Inspection" within thirty (30) days after completion of such inspection and test.

(7) Certificate of Inspection

As soon as the inspection and test as specified in the Contract have been satisfactorily completed and the corresponding reports have been accepted by the PMO/Engineer in accordance with the requirements of subclause "(4) Inspection and Testing During Manufacture - Reports of Inspection and Tests" , the PMO/Engineer will issue a "Certificate of Inspection" per every shipment/delivery in which he shall certify the date on which the said inspection and test have been completed and the particulars of the gate inspected and test referred. Issuance of such Certificate of Inspection shall not release the Contractor from any of his obligations under the Contract.

(8) Rectification of Deficiencies

All deficiencies revealed by testing and inspection shall be rectified by the Contractor at his own expense and to the approval of the PMO/Engineer. Rectified components shall be subject to retesting and reinspection.

(9) Cost of Tests not Provided for, etc.

If any test is ordered by the PMO/Engineer which:

(a) is not so intended by or provided for in the Contract,
(b) is not so particularized, or
(c) though so intended by or provided for is ordered by the PMO/Engineer to be carried out by an independent person at any place other than the place of manufacture or fabrication of the materials tested,

then the cost of such test shall be borne by the Contractor if the test shows the workmanship or materials not to be in accordance with the provisions of the Contract or the PMO/Engineer's instructions but if the results of the test show otherwise the cost of such test shall be borne by the Employer.

(10) Time for Tests

If the PMO/Engineer fails to appoint a time after having been asked to do so, or does not attend at the time and place appointed, the Contractor shall be entitled to proceed with the Tests in his absence. The Tests shall then be deemed to have been made in the presence of the PMO/Engineer and results of the Tests shall be accepted as accurate.

(11) Delayed Tests

If the Tests are being unduly delayed by the Contractor the PMO/Engineer may, by notice in writing, call upon the Contractor to make the Tests within 21 days after the receipt of such notice. The Contractor shall make the Tests on such days within that period as the Contractor may fix and of which he shall give notice to the PMO/Engineer.

If the Contractor fails to make the Tests within 21 days the PMO/Engineer may himself proceed with the Tests. All Tests so made by the PMO/Engineer shall be at the risk and cost of the Contractor and the cost thereof shall be deducted from the Contract Price. The Tests shall then be deemed to have been made in the presence of the Contractor and the results of the Tests shall be accepted as accurate.

(12) Repeat Tests

If the Works or any section fails to pass the Tests, the PMO/Engineer or the Contractor may require such Tests to be repeated on the same terms and conditions. All costs to which the Employer may be put by the repetition of the Tests under this clause or under Clause 49 "Maintenance and Defects" of Conditions of Contract shall be deducted from the Contract Price.

A.1.7 Packing for Shipment

Each item shall be packed properly or protected for shipment from the place of manufacture to the Site.
Each crate or package shall contain a packing list in a waterproof envelope and a copy in triplicate shall be forwarded to the PMO/Engineer prior to deliver. All items of material shall be clearly marked for easy identification against the packing list.

All cases, packages, etc., shall be clearly marked on the outside to indicate the total weight, to show where the weight is bearing and the correct position of the slings and shall bear an identification mark relating them to the appropriate shipping documents.

Cases which cannot be marked as above shall have metal tags with the necessary marking on them. The metal tags shall be securely attached to the package with strong steel wire or equivalent.

The PMO/Engineer shall reserve the right to inspect and approve the equipment and the packing before the items are delivered. The Contractor shall be entirely responsible for ensuring that the

packing is suitable for transit and such inspection will not relieve the Contractor from responsibility for any loss or damage due to faulty packing.

All packing materials shall remain the property of the Contractor and shall be removed from the Site at the earliest opportunity and be disposed at the places/areas which will be instructed by the PMO/Engineer.

A.1.8 Change to Material or Equipment

The Contractor shall not make any changes to the equipment or in the materials to be incorporated in the equipment from that specified or implied by these Specifications without the written approval of the PMO/Engineer. Such changes or alterations shall in no way be detrimental to the interests of the Employer and shall not result in any increase to the Contract Price.

A.1.9 Delivery

(1) Delivery of Gate

Unless directed otherwise by the PMO/Engineer, no part of the gate shall be shipped to Site until the PMO/Engineer has issued certificates under Clause A.1.6 "Inspection and Testing During Manufacture". Likewise the gate or Contractor's Equipment shall be delivered to the Site only upon an authorization in writing applied for and obtained by the Contractor from the PMO/Engineer.

The Contractor shall be responsible for the reception on Site of the gate and Contractor's Equipment.

(2) Notice of Delivery

The Contractor shall inform the PMO/Engineer and the Employer of the details of the gate, materials and Contractor's Equipment for use on the Works sufficiently in advance (minimum 30 days) of shipment. The Employer will assist the Contractor, where required, in obtaining customs clearance for the gate, materials, and Contractor's Equipment which have to be imported into Mauritius and in obtaining all necessary Government permission to remove and re-export the Contractor's Equipment after completion of the Works.

(3) Documents for Delivery

Upon shipment of each package or item, copies of shipping documents comprising Bill of Lading, Detailed Invoice, Packing List, Insurance Policy and the PMO/Engineer's

Inspection Certificate shall be received by the Employer and the PMO/Engineer, at least 10 days before arrival of cargoes at the Port of Destination.

(4) Damages During Transportation

The Contractor shall be responsible for the sea and land transportation without any loss or damage of material, equipment and Contractor's Equipment to be used for construction, operation, maintenance and testing of the Works from their place of origin to the Site and more precisely to their point of utilization at the Site. All costs related therewith shall be at the Contractor's charge. The Contractor in his own interest should check the capacity of the loading and unloading facilities available as well as the limitation in respect of roads, bridges, railways, etc.

Any damage to roads, bridges, railways, etc. arising out of neglect by the Contractor or his Subcontractors shall be the responsibility of the Contractor.

(5) Transportation Equipment

The Contractor is obliged to make the necessary arrangement in hiring a forwarder to coordinate and manage the transportation of the gate or a part thereof from the manufacturer's workshop to the Port of Destination. Such firm or forwarder shall be experienced and qualified and as may be designated by the Employer or as may be mutually agreed before signing the Contract.

The Contractor shall deliver all materials and equipment including Contractor's Equipment supplied under the Contract to the Site in adequate time for its preparation and erection according to the Approved Work Program.

Notification of such delivery shall be given to the Employer and the PMO/Engineer in writing not later than thirty (30) days prior to the actual shipping date for any equipment to be shipped.

Each notification shall include a complete shipping list of the contents of each package to be delivered and shall indicate the anticipated date of delivery and the serial number for each component to be used for identification and evidence of the insurance cost arranged for it.

The Contractor shall be responsible for the reception at the Site of all deliveries for the purpose of the Contract.

The Contractor shall at his responsibility inspect the cargoes at the Site upon arrival of the cargoes and shall report in writing the particulars, quantities, conditions, damages, if any, of the cargoes to the Employer within three (3) days after arrival.

A.1.10 Installation and Tests at the Site

(1) General

The Contractor shall provide all the necessary heavy equipment for handling, storage, transportation to the erection site, launching for the gates and all other necessary tools and other devices. The cost for these equipment and tools shall be deemed to be included in the contract price.

During the construction and after the installation work of each item of equipment, the Contractor shall perform the tests as described in the test procedure to establish the accuracy of assembly and to prove the adequacy of the materials and workmanship.

The tests and test procedure shall be approved by the PMO/Engineer. No part of the work shall be considered acceptable until it has successfully complied with these test to the satisfaction of the PMO/Engineer.

(2) Notice of Tests on Completion

The Contractor shall give to the PMO/Engineer 30 day's notice of the date after which he will be ready to make the Tests on Completion (the Tests). Unless otherwise agreed, the Tests shall take place within 10 days after the said date on such day or days as the PMO/Engineer shall notify the Contractor.

(3) Facilities for Tests on Completion

The Contractor, except where otherwise specified, shall provide free of charge subject to the provisions of subclause "(4) Retesting" such labour, materials, electricity , fuel, water, stores and apparatus as may be required and as may be reasonably demanded to carry out such tests efficiently.

(4) Retesting

If the works or any section fails to pass the tests, tests of the said portion shall, if required by the PMO/Engineer or by the Employer, be repeated within a reasonable time upon the

same terms and conditions, save that all reasonable expenses to which the Employer may be put by the repetition of the tests shall be deducted from the contract price.

(5) Consequences of Failure to Pass Tests on Completion

If the Works or any section fails to pass the Tests on the repetition thereof under subclause "(4) Retesting", the PMO/Engineer, after due consultation with the Employer and the Contractor, shall be entitled to:

(a) order one further repetition of the Tests under the conditions of subclause "(4) Retesting", or

(b) reject the Works or section in accordance with Clause 36 of Conditions of Contract, or

(c) issue a Taking-Over Certificate, if the Employer so wishes, notwithstanding that the Works are not complete. The Contract Price shall then be reduced by such amount as may be agreed by the Employer and the Contractor or, failing agreement, as may be determined by arbitration.

(6) Test Reports on Completion

The Contractor shall submit to the Employer and to the PMO/Engineer with ten (10) copies of all test reports within thirty (30) days after completion of the Tests.

A.1.11 Embedded Steelwork, Opening, etc.

Unless otherwise specified, any foundation, wall and roof openings and coverings, concrete floor filling and sleeves in the foundation and wall will be provided by the Contractor.

The Contractor shall design, supply and install, as part of this Contract, all anchors, fasteners, foundation bolts and nuts, braces, posts, supports, shims, pipings, conduits, sleeves, access ladders and platforms, handrails, cover plates and curbings, hangers, hooks, gratings, traps and other miscellaneous metal works around the gate, and all steel works as may be required for temporary or final support of anchorage of the gate, which are indispensable for, associated with and required for the gate to be provided and installed under this Contract, except as otherwise provided in the Specifications and Drawings for Tender.

The Contractor shall indicate on his drawings full details of foundations, openings, blockouts and all anchor components required in both primary and secondary concrete structures and shall be responsible for the timely supply, completeness and accuracy of his drawings and the other related information which will be supplied and/or given to the Employer for further works, through approval procedure as mentioned in clause A.1.1 "Drawings and Documents to be Supplied by the Contractor" herein.

Any steelwork which is to be built into the concrete foundations shall not be painted or coated.

During installation of all embedded steel pipes, the openings of each pipe end shall be plugged by suitable covers which shall be removed after completion.

Structural steel supports and facilities for anchors shall be supplied and installed under this chapter to prevent displacement or uplift of the embedded component due to buoyancy or external forces that may occur during placing concrete.

A.1.12 Instructions for Erection Works

The Contractor shall submit to the PMO/Engineer for approval not later than three (3) months before the start of erection the instruction manual for the erection work of the gate to be executed at the Site.

The instruction manual shall be submitted for approval in the same manner as the drawings and, when finally approved, three (3) copies shall be submitted to the Employer and two (2) copies to the PMO/Engineer. The Contractor shall ensure that the erection supervisor has a copy in his office at the Site.

The instruction manual shall describe and illustrate in detail the methods and procedures for installation of the gate, the use of the construction facilities and measurement devices together with their capacity and required number, field shop to be provided for the installation work and other necessary explanations on the installation work.

A.1.13 Work Manual

The manual required for maintenance and closing/lifting operation works of the diversion closing gate shall be prepared in the English Language and submitted for approval in the same manner as drawings and documents and when finally approved, seven (7) copies and three (3) copies shall be prepared and forwarded to the Employer and the PMO/Engineer respectively.

The work manual shall be described in details with illustration each procedure for maintenance and closing/lifting operation of the diversion closing gate, inspection records for the installed components and the use of all equipment, tools and measuring devices, etc. required for the works for the further maintenance and closing/lifting operation to be performed by other contractor.

A.2 Design Criteria and Particulars

A.2.1 Loads to be Considered

(1) Design Load Conditions

The equipment shall be designed with the worst or possible combination of the following loading conditions with the assumption that in no case the seismic and wind loading occur simultaneously for the equipment/structures:

- All hydrostatic and dynamic loads due to design water head,
- All loads due to dead weight and frictional forces,
- All loads due to characteristics of electric motor used,
- Seismic or wind loads, and
- Other loads

All or part of the loads specified herein shall be considered as requirements and the Contractor shall use additional loads and combinations thereof which the Contractor considers to be applicable and necessary.

(2) Seismic Load

No seismic load shall be taken into consideration for the hydromechanical works included in the Contract (Lot-I) in view that those are temporary equipment.

(3) Wind load

The following wind load shall be applied by the type of structures to be designed:

- For plane surface	:	150 kgf/m^2
- For a cylindrical surface	:	100 kgf/m^2
- For lattice member, windward	:	150 kgf/m^2
- For lattice member, leeward	:	75 kgf/m^2

(4) Other Loads

- Crowded load on footpath, balcony floor, platform, etc. : 500 kgf/m^2
- Crowded load on access bridge on aqueduct : 100 kgf/m^2
- Vertical load on each step of ladder : 180 kgf

A.2.2 Design Stresses for Gates and Other Steel Structures

(1) Structural Steel Members

(a) The allowable stresses for normal loading condition of structural steel members with a thickness of 40 mm or less shall be as shown in the following table:

	Steel Material	SS41 and SM41B thickness ≤ 40 mm	SM50B thickness ≤ 40 mm
1.	Axial tensile stress (per net sectional area)	1,800 kgf/cm^2	2,400 kgf/cm^2
2.	Axial compressive stress (per gross sectional area)	On condition of (l/r)≤20, 1,800 kgf/cm^2	On condition of (l/r)≤15, 2,400 kgf/cm^2
	Compressive members	On condition of 20<(l/r)≤93, 1.5[1,200-7.5{(l/r)-20}] kgf/cm^2	On condition of 15<(l/r)≤80, 1.5[1,600-11.2{(l/r)-15}] kgf/cm^2
		On condition of 93<(l/r), $\frac{15,000,000}{6,700 + (l/r)^2}$ kgf/cm^2	On condition of 80<(l/r), $\frac{15,000,000}{5,000 + (l/r)^2}$ kgf/cm^2
	where, l: buckling length of member (cm) r: radius of gyration of sectional area of member (cm)		
	Compressive splice member	1,800 kgf/cm^2	2,400 kgf/cm^2
3.	Bending tensile stress (per net sectional area)	1,800 kgf/cm^2	2,400 kgf/cm^2
	Bending compressive stress (per gross sectional area)	On condition of (l/b) ≤ (9/K) 1,800 kgf/cm^2	On condition of (l/b) ≤ (8/K) 2,400 kgf/cm^2
		On condition of (9/K)<(l/b)≤30, 1.5[1,200-11{(Kl/b)-9}] kgf/cm^2	On condition of (8/K)<(l/b)≤30, 1.5[1,600-16{(Kl/b)-8}] kgf/cm^2
	b: width of compressive flange (cm) K: $\sqrt{3 + Aw/2AC}$ Aw: sectional area of web plate (cm^2) Ac: sectional area of compressive flange (cm^2) In case of (Aw/Ac)<2, K is taken as 2,		
	On condition that compressive flange is directly welded to skin plate, etc.	1,800 kgf/cm^2	2,400 kgf/cm^2
4.	Shearing stress (per gross sectional area)	1,050 kgf/cm^2	1,350 kgf/cm^2

Notes: 1) In case the thickness exceeds 40 mm, the allowable stresses for normal loading condition of the structural steel members shall be adjusted as follows:

The stress shall be 0.92 time that of the allowable stress as mentioned above in the case of steel material SS41 and SM41B, and 0.94 time for steel material SM50B.

2) SS41 (JIS G 3101)
SM41B and SM50B (JIS G3106)

(b) The allowable stresses, in no case, shall exceed 90 percent of the yield point strength and/or minimum elastic limit of the steel material used.

The combined stress shall be calculated with the following formula as developed by Mises, Hencky and Huber:

$$fg^2 = fx^2 + fy^2 - fx \times fy + 3fq^2$$

where,

fg : combined stress (kgf/cm^2)
fx : direct stress (tension is considered as positive) (kgf/cm^2)
fy : direct stress acting perpendicular to axis of fx (tension is considered as positive) (kgf/cm^2)
fq : shearing stress (kgf/cm^2)

(c) When steel material other than those mentioned in the table of paragraph (a) of this clause is used, its allowable tensile stress for normal loading condition shall not exceed 50 percent of the yield point strength of the steel material used. All other allowable stresses shall be computed in proportion to the allowable stresses given in the table of paragraph (a) of this clause based on the yield point of steel material used.

(2) Machine parts

All mechanical parts of the hoisting equipment subject to normal or rated capacity loading condition shall be designed with the following factors of safety (FS) against the ultimate strength of the steel material used.

Material	FS for Tensile Stress	FS for Compre-ssive Stress	FS for Shearing Stress
Rolled steel for general or welded structure	3.3	3.3	5.8
Carbon steel forgings	3.3	3.3	5.8
Carbon steel for machine structural use	3.3	3.3	5.8
Corrosion-resisting steel	3.3	3.3	5.8
Carbon steel castings	3.3	3.3	5.8
Gray iron casting	6.7	2.3	6.7
Bronze castings	5.3	5.3	6.7

Note: Unit stress shall not exceed ninety (90) percent of the yield stress of the material used under the loading resulting from the breakdown or locked-rotor torque of the hoist motor, whichever is greater.

(3) Concrete stress

The allowable concrete bearing and shearing stress shall not exceed the following:

Concrete	SIG 28 (kg/cm^2)	Allowable Stress (kg/cm^2)			
		Bearing		Shearing	
		Normal Loading	Tentative Loading	Normal Loading	Tentative Loading
Plain	180	40	60	4.5	6.75
Reinforced	180	54	81	4 (8)*	6 (12)*
"	210	63	94.5	4.25 (8.5)*	6.37 (12.75)*

*: The first value is for beams and that n bracket is for slabs.

A.2.3 Minimum Thickness

The minimum thickness of the major structural members shall be 6.0 millimeters, except for the following parts:

Parts	Min. Thickness (mm)
Skin plate of diversion closing gate leaf	12.0
Corrosion-resisting steel plate for:	
Sealing plates on side and lintel beams	6.0
Sealing plates on sill beams	9.0
Track and bearing plates	9.0
Others	6.0

A.2.4 Critical Slenderness Ratio

The critical slenderness ratio for major compression members shall be less than 120, and 150 for secondary members. The said ratio in case of tension members shall be read as 200 and 240 respectively.

A.2.5 Maximum Deflection

The maximum deflection of each component of the equipment shall be less than the following value at full load against the supporting span:

Max. Deflection	Equipment
- 1/800	Main beam of all the gates
- 1/1,500	Top beams

A.2.6 Corrosion Allowance

No corrosion allowance for the equipment and structures may be taken.

A.2.7 Coefficient of Friction

For the purpose of designing the equipment, the coefficient of friction shall not be less than the following:

	Static Friction	Kinetic Friction	
		Max.	Min.
	(Starting)	(whichever gives worse case)	
Metal to metal	0.6	0.5	0.3
Rubber seals	1.5	0.9	0.6
Brass-faced seals	0.42	0.3	0.2
Fluoro-carbon faced seals	0.2	0.15	0.1
Self-lubricating bearings	0.2	0.11	0.05
Roller wheel bearings	0.015	0.01	0.004

A.2.8 Rubber Seals for Gates

Seals shall be designed and mounted in such a manner that they are adjustable, water tight and shall be readily removed and replaced.

Seals shall be moulded. Extruded seals will not be permitted. Where seals are installed curved, they shall be clamped in a jig which will form them to the proper radius before the holes are laid out and drilled, and the ends trimmed. Holes in related parts of the seal assemblies shall be carefully drilled, using a template, to assure proper matching when the seal units are assembled. Arrangements shall be made to provide effective continuity of sealing at the corners of the gates.

All adjusting screws, bolts and washers for securing the seals and seal assembly in place shall be of corrosion resisting steel.

Seals shall be made of natural or synthetic rubber suitable for the temperature ranges and conditions at the Site and shall be of a material that has proven successful in similar applications. Joints shall be water tight and seal materials shall have the following physical properties as determined by tests made in accordance with the relevant standards:

Property	Limits
Tensile Strength	210 kgf/cm^2 minimum
Ultimate Elongation	450 percent minimum
Durometer Hardness (Shore, Type A)	60 to 70
Specific Gravity	1.1 to 1.3
Water Absorption (70°C for 48 hours)	5 percent maximum by weight
Compression Set (as a percent of total original deflection)	30 percent maximum
Tensile Strength after oxygen bomb aging (70°C for 48 hours)	80 percent minimum of tensile before aging

A.2.9 Materials

All materials in structure of the gate covered in this chapter shall be new and of high quality, selected particularly to meet the duties required for the proper operation of the gate, and indicated fully in the Contractor's detailed drawings for approval.

The materials shall meet with the requirements in the latest Japanese Industrial Standards (JIS) listed herein or equivalent and/or better in quality or as approved in advance by the PMO/Engineer unless otherwise specified.

(1) Steel plates, bars and pipes etc.

(a)	Steel plates for gate leaves	Fully killed steel as specified in JIS G3106, i.e. SM41B and AM50B where applicable
(b)	Steel plates for general structures	JIS G3101, SS41
(c)	Rolled steel shapes	JIS G3192 and JIS G3101 SS41 JIS G3106 SM41, SM50
(d)	Steel bolts, nuts and washers	JIS B1180, B1181 and B1256
(e)	High-strength steel hexagon bolts, hexagon nuts and plain washers for friction grip joint	JIS B1186
(f)	Spring lock washers	JIS B1251
(g)	Corrosion-resisting steel plates and bars etc.	JIS G4303, G4304, G4305, G4306 and G4307
(h)	Corrosion-resisting clad steel plates	JIS G3601

(2) Castings

(a)	Iron castings	JIS G5501, FC25
(b)	Steel castings (to be fully annealed)	JIS G5101, SC42
(c)	High tensile strength carbon and low alloy steel castings	JIS G5111,SCMnCr 3B

	(d)	Bronze castings	JIS H5111, BC6
	(e)	Phosphor bronze castings	JIS H5113, PBC2
(3)	Forgings		
	(a)	Carbon steel forgings	JIS G3201, SF40
(4)	Miscellaneous materials		
	(a)	Self-lubricating bearing	JIS H 5102, high strength brass casting, HBsC4 (Min.HB 210) incorporated with the solid lubricant
	(b)	Stranded wire ropes or 6xF1(29) construction (galvanized) Langs Z or S lay construction	JIS G 3525,Grade G, 6x37
	(c)	Wire rope fittings	Manufacturer's standard fittings for the type of wire rope used
	(d)	Steel conduit for air and water piping	JIS G 3452
	(e)	Steel conduit for electric wiring	JIS C 8305

A.2.10 Lubrication

Before assembly, all bearing surfaces, journals, and grease and oil grooves shall be carefully cleaned and lubricated with an approved oil or grease. After assembly, each lubricating system shall be filled with an approved lubricant. Self-lubricating bearings shall be cleaned with clean rags, and greased with an approved lubricant before assembly. Solvent shall not be used on the self-lubricating bearings. The specification of all approved lubrications shall be mentioned in the Operation and Maintenance Instructions.

Provision shall be made for lubricating all bearing, including ball and roller bearings, by a pressure gun system. All lubrication nipples shall be readily accessible.

Where accessibility to a bearing for lubricating purposes is difficult, provision shall be made for remote lubrication or safe access to the lubrication point.

Ball and roller bearings shall be packed with grease during initial assembly.

All bearings and gear cases shall be made grease and oil-tight and drip pans shall be provided where necessary to prevent excess oil or grease dripping to the floor or deck.

The Contractor shall submit a list of lubricants and recommended storage quantities to be held at the site. The Contractor shall provide one hundred and ten percent (110%) of all kinds of oils and greases required for initial filling. The oil and grease shall be of a type available in Mauritius as approved by the PMO/Engineer, if applicable. The type available in Mauritius shall be investigated by the Contractor himself.

A.2.11 Fabrication

The equipment shall be designed and fabricated in accordance with the relevant standards, unless otherwise specified.

Fabrication of plate and structural steel work shall be performed in accordance with the best modern practice, true to line and free from warp or twist.

The connection between each structural member shall be made by means of bolting or welding and designed in such a manner that all forces are transmitted wholly by bolting or by welding. No sharing of specific load by two types of connection shall be accepted.

When bearing type bolts are used, they shall be so proportioned that the unthreaded part of the bolts shall resist the load at the reamed holes of the materials together with washers having a minimum thickness of 5 mm . For all sloping surfaces, bevelled washers shall be provided. For high strength tensile bolt connections, lock nuts and washers shall be provided.

All edges of plates to be welded shall have the edge prepared by machining or other approved methods so as to be suitable for the type of weld employed.

Where damage occurs in transit, the Contractor shall specify the technique of repair and obtain written approval of the PMO/Engineer before proceeding with such repair.

A.2.12 Mechanical Parts for Equipment

The mechanical equipment and parts for the gate shall conform to the following requirements unless otherwise specifically mentioned:

(1) Ropes, Drums and Sheaves

The hoisting rope, except where otherwise noted, shall be galvanized, flexible, improved plough steel wire type with fiber core and internal lubricant.

The factor of safety of the hoisting shall not be less than eight (8). The required breaking strength of the rope shall be specified in the Contractor's order to the rope manufacturer.

The rope systems shall be equalized and arrangements entailing reverse bends shall be avoided wherever possible.

Rope drums shall be of cast iron, cast steel or fabricated steel with machined grooves. Paired rope drums shall have the same diameter to the bottom of the groove. Grooves shall be smooth machined with an adequate depth. Drums shall have sufficient width to wrap the full length of rope, and two and a half grooves when the gate/stoplog is fully closed position.

The rope end shall be secured to the outside of the drum by means of a clamp or other approved means. The fastening shall be easily accessible to facilitate rope removal or replacement.

The minimum pitch diameter of rope drums and sheaves shall be 19D and 17D for 6 x 37 construction rope respectively, where D is the diameter of the rope.

Fleet angles for grooved rope drums and sheaves shall not exceed 4 degrees.

Rope sheaves shall be Vee-grooved with an included angle of 52 degrees and groove depth equal to 1.5 times the rope diameter. The groove diameter shall be slightly in excess of the rope diameter to prevent pinching. The hook for sheave block shall be capable of rotating freely.

(2) Bearings

Bronze bushed bearings shall be used for all low speed shafts, and high speed ball or roller bearings shall be used for all other locations.

Shafts and bearings shall be proportioned so that the length does not exceed one and one half times the shaft diameter for bronze bearings not so as to exceed an allowable bearing stress at the projected area.

(3) Keys and Keyways

Keys and keyways shall be designed in accordance with the relevant standards. Where taper keys are used, they shall be provided with a gib head or other suitable provisions to facilitate withdrawal. Feather keys shall be secured in position by means of counter-sunk screws through the key.

A.3 Detailed Specifications for Diversion Closing Gate

A.3.1 General

One set of vertical lift slide type diversion closing gate, with guide frames, steel top beams, wire rope and appurtenant parts complete with all necessary accessories, except for the wire rope winch to be used for operation of gate, shall be designed, supplied and installed in the inlet structure of diversion tunnel. The diversion closing gate shall be used for turning off river flow from the diversion tunnel to the original riverbed and subsequent installation of river outlet facilities in the diversion tunnel, after completion of the dam with a temporary winch.

The gate shall be designed to be capable of closing and opening under any conditions given hereinafter. Guide frames of the gate shall be installed prior to the river diversion work. The Contractor shall operated the gate as directed by the PMO/Engineer.

The Contractor shall exercise special care in the design of the gate to avoid any vibration during operation of the gate and any water leakage under the fully closed condition. The general data for the design of the diversion closing gate in sub-clause A.3.3 "Design Data" shall not be altered. The arrangement of the diversion closing gate and top beams shall be as shown on the Drawing No. M-001.

The diversion closing gate may be submerged during the dam construction work by Lot-II. During the dam construction work, the diversion closing gate and appurtenant parts shall safely be protected with a suitable cover sheet.

A.3.2 Design Stresses

Design stresses shall conform to those specified in sub-clause A.2.2.

A.3.3 Design Data

(1) General data

Type of gate	:	Steel slide gate
Quantity to be provided		
Gate leaf	:	1 set
Guide frame	:	1 set
Top beams	:	1 set
Clear span of gate	:	6,800 mm
Clear height of gate	:	6,800 mm
Design head	:	60.000 m
Operation head	:	3.000 m
Sill elevation	:	EL.129.000 m
Water seal	:	4 edges rubber seal at downstream face of gate
Type of hoist tower	:	Reinforced concrete type
Hoisting height	:	9.500 m
Operation method	:	By portable wire rope winch

(2) Gate

(a) Hydrostatic load

Head water at elevation of 189.000 meters and tail water below sill beam at elevation of 129.000 meters.

(b) Operation

The gate will be raised and lowered under imbalanced water head condition of EL. 132.00 meters.

The gate shall be capable of closing the inlet opening of diversion tunnel upon overcoming all frictional resistance force due to bearing plate, seals, side rollers and so forth when the gate being lowered by its own weight to shut off full water flow to the diversion tunnel.

(c) Other loads

Reaction due to its own weight. All loads imposed during starting, raising and lowering the gate, including any hydrodynamic force acting on the upstream face of the gate.

(d) Overload conditions

All loads imposed during operation, due to the gate jammed condition.

(3) Guide frame

The loading on the guide fame shall be the bearing and seal load, and all other loads due to the most adverse operation of the gate. The guide frame and its anchors shall be capable of transferring all the loads to the concrete structure and of preventing harmful deflection of guide frame due to placing concrete.

(4) Top Beams

The top beams shall be provided at the top of the diversion concrete structure to raise, lower and hold the gate in any position between fully lowered and fully raised positions. The capacity of the top beams shall be adequate to raise, lower, and hold under the most adverse combination of the loads due to hydraulic loads specified in this subclause. The requirements for frictional coefficients shall conform to the requirements of sub-clause A.2.7 " Coefficient of Friction " of the Technical Specifications.

A.3.4 Gate Details

(1) General

The gate shall consist of skin plate, main beams, bearing plate, seals, side rollers, lifting attachments and all other necessary components. The gate shall be of the slide gate and of all welded construction.

The seal weld shall be made where required for the water tightness.

The details of the construction of the gate not specified herein will be left to the Contractor, upon approval of the PMO/Engineer.

(2) Skin plate

The skin plate shall be at the downstream face of the gate.

(3) Main beams

The main horizontal beams shall be of H-beam or built-up plate girder construction.

(4) Side rollers

Two (2) side rollers shall be provided on each side of the gate to limit the lateral movement of the gate. The side rollers shall be provided with the self-lubricating bushings with the lubricating system as referred in paragraph 4 of this subclause and corrosion resisting steel pins and location washers.

The roller and pin shall be designed to resist the load imposed due to the gate being jammed in the guide frame. The locations of side rollers shall be developed based on the structures of side guide frames at the inspection pits as referred to in paragraph 6 of sub-clause A.3.5 "Guide Frame Details", so as to always ride on the side roller paths of the side guide frames for smooth operation of the diversion closing gate.

(5) Seals

The gate seals shall be of the moulded rubber shape clamped to the downstream face of the gate using bars, bolts, nuts and washers. The side and lintel seals shall be of the caisson type or other approved shape activated to the water pressure. The bottom seal shall be of the plain rubber which bear on the sill beam.

(6) Tolerances

The gate shall be accurately fabricated and installed within the following tolerances:

Points to be measured	Tolerances (mm)
Gate width	±7
Gate height	±7
Gate depth	±3
Diagonal length difference	±8
Distance between bearing plates	±7
Distance between side roller paths	±7

Position of side rollers	± 6
Distance between side seal rubbers	± 10
Distance between bottom seal and top seals	± 7

The tolerances not specified herein shall be made by the Contractor, upon approval of the PMO/Engineer.

A.3.5 Guide Frame Details

(1) General

The guide frame shall consist of sill beam, side frames and all other necessary components for the complete and satisfactory installation of the guide frames. The details of construction of the guide frame not specified herein shall be made by the Contractor, upon approval of the PMO/Engineer.

(2) Sealing frames

The sealing frames shall consist of sealing plates made of corrosion resisting steel and attached to the surfaces of sealing frame. When the guide frame has been assembled, all the sealing surfaces shall be straight, true and in the same plane within the specified tolerances.

(3) Lintel beam

The lintel beam having the sealing plate made of corrosion resisting steel thereon shall be true to form and free from twist and warp to provide a watertight seal with the gate top seal. Armoured plate against erosion shall be provided on the beam.

(4) Track frames

The track frames shall be capable of transmitting the water load from the bearing plate of the gate to the concrete structure. The surface of the track frames shall be provided with the corrosion resisting steel bearing plates and be true and flat. The surfaces shall be suitably machined and have the hardness rather higher than that of the contact surface of bearing plates of the gate to prevent excessive wear. The track frame shall be provided up to EL. 137.000 meters.

(5) Sill beam

The sill beam shall be straight and true to provide a close fit with the bottom seal of the gate. The corrosion resisting steel sealing plate shall be attached to the above surface of the sill beam. The surface of the sill beam shall be flushed with the intake canal sill and shall be fitted and attached to the side guide frames at the corners to form a continuous seal when the gate is fully closed.

(6) Side guide frames

The side guide frames consist of the side roller paths and frames. The side guide frames shall have ample strength to resist the load of the side rollers. The assembled side roller paths and the surfaces of side guide frames shall be provided up to EL. 146.500 meters.

(7) Dogging Devices

The Contractor shall provide one set of dogging devices at the diversion closing gate slot at EL.138.000 level. The dogging devices shall be designed to support and hold the gate leaf. The details of the construction of dogging devices, not specified herein, shall be left to the Contractor, subject to approval of the PMO/Engineer.

(8) Tolerances

The guide frames shall be accurately fabricated and installed within the following tolerances:

Points to be measured	Tolerances (mm)
Clear span	± 7
Sealing span	± 7
Distance between track frames	± 7
Height of guide frames	± 8
Distance between side roller paths	+ 8, - 0
Flatness of side sealing surface	± 0.5/m
Straightness of side sealing frames	± 1
Flatness of sill beam surface	± 0.5/m
Straightness of sill beam surface	± 2
Flatness of track frame surface	± 0.5/m
Straightness of track frame surface	± 1
Straightness of side roller paths	± 5

The tolerances not specified herein shall be made by the Contractor, upon approval of the PMO/Engineer.

A.3.6 Top Beam Details

One (1) set of top beams shall be provided at the upper position of the concrete structure to operate the gate and consist of upper and lower sheave blocks and all other necessary components. The capacity of the top beams shall be ample to operate the gate under any possible operating conditions. The details of the top beams, not specified herein, will be left by the Contractor, subject to approval of the PMO/Engineer.

A.3.7 Installation at Site

The gate leaf complete with the seals, guide rollers and arms shall be assembled and erected in accordance with the details shown in the final approved drawings and in accordance with the PMO/Engineer's instructions. Joints shall be watertight where required. The bottom of the gate, when erected, shall be in true alignment to ensure a tight and even bearing of the skin plate and rubber seal on the embedded sill beam. The sides of the gate shall be in true alignment so that the rubber seals, when installed, will have tight and even bearing on the sealing surfaces embedded in the concrete. It shall be the Contractor's responsibility to establish the field tolerances necessary to meet the specified tolerances.

The guide frames shall be assembled in their blockouts in accordance with the final approved drawings, brought to line and grade within the tolerances specified and firmly secured in place. Alignment bolts or other necessary devices shall be used to install the guide frames, at corresponding accurate position. Corrections between the guide frames, anchored materials and the alignment devices shall be adjustable and firmly tightened to hold the guide frames securely in position while concrete is being place in the blockouts. Additional bracing shall be provided where necessary to ensure the required alignment.

Extreme care shall be taken to ensure that the guiding, bearing and sealing surface lie in a true plane within the tolerances specified in their entire length. Placement of concrete in the blockouts shall not proceed until the guide frames have been completely assembled and secured. During placing of concrete, alignment and tolerances shall be checked and remedial action taken if readings indicate that displacement has occurred.

A.3.8 Test on Completion

After completion of the installation work at the Site, the tests shall be performed by the Contractor in accordance with the approved test procedure which contains the test following items :

(a) Inspection by feeler gauge measurement of satisfactory seating of all seals,

(b) Inspection for satisfactory installation of all components.

(c) Check of satisfactory operation under dry condition

A.4 Measurement and Payment

Measurement for payment for the hydromechanical works shall be made on the basis of the unit of the respective items stated in the Bill of Quantities for actually installed hydromechanical works in accordance with the Drawings and Specifications and as directed by the PMO/Engineer.

Payment will be made for quantities measured in the respective items stated in the Bill of Quantities at the respective unit price stated in the Bill of Quantities. The unit price shall cover the supply, fabrication, transportation, installation, testing and any other relevant works required.

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